““THE HAWAIIAN
PLANTERS’ RECORD

Volume XXI. AUGUST, 1919 Number 2

A monthly paper devoted to the sugar interests of Hawaii and issued by the Experiment Station for circulation among the Plantations of the Hawaiian Sugar Planters’ Association.

A Short Course for Plantation Men.

Beginning October 20, the College of Hawaii, co-operating with this Experiment Station, will conduct a two weeks’ course dealing with sugar-cane agriculture. The lectures and demonstrations will be of a concise and practical nature. They will be devoted to the fundamental principles underlying higher sugar production.

Several subjects will receive attention. Insect pests and their control by parasites will be discussed, as will cane diseases, and the methods to hold them in check. Commercial fertilizers are to be dealt with fully and their composition and use explained. The improvement of irrigation methods by the use of soil moisture studies, as followed in the West, together with the possibility of adapting these investigations to local conditions, will be considered.

The course embraces other topics pertinent to the work in hand.

The plantations generally have endorsed the plan. The following brief extracts from letters on the subject reflect the support the course is receiving:

''This plan has our hearty approval.''—F. A. Schaefer & Co., Ltd.

''I think this is an excellent plan.''—W. W. Goodale.

''I am very much in favor of this idea * * * and I am willing to cooperate.''—Geo. F. Renton.

''This idea has our hearty endorsement.''—Castle & Cooke, Ltd.

''I think the short course * * * would prove of material benefit.''—H. A. Baldwin.

''If the course of instruction is what it should be, it will probably be of great value to the plantations.''—F. F. Baldwin.

''I am very much in favor of * * * the proposed short course.''—B. D. Baldwin.

''I am much interested in the proposed two weeks short course.''—F. A. Alexander.

''We are pleased to learn of your plan to conduct a two weeks short course.''—Hind, Rolph & Co.

''This course meets with our hearty approval.''—C. Brewer & Co., Ltd.

''We have received letters from Mr. Moir, Mr. Webster, Mr. Ross, * * * Mr. Gibb, Mr. Henderson, Mr. Penhallow * * * all approving the sugar course to be established by yourselves and the College of Hawaii.''—C. Brewer & Co., Ltd.

''We will support this movement as far as possible.''—Oahu Sugar Co.

''We approve and will send one or two of our overseers.''—Makee Sugar Co.

''We will be pleased to cooperate in any way we can.''—Pioneer Mill Co.

''We approve this step.''—Olaa Sugar Co.

Phosphoric Acid Experiments at Hakalau.

The object of these experiments was to study phosphoric acid fertilization under conditions prevailing along the Hilo coast on land that had been cropped continuously for thirty-two years.

The questions asked were:

(1) What is the value of phosphoric acid as a plant food for sugar cane when used as a supplementary application to nitrogen?

(2) What form of phosphoric acid is best adapted to conditions found at Hakalau?

(3) Is the Wyoming raw rock phosphate as valuable fertilizing material as reverted phosphate when equal money values of each are compared?

(4) Would phosphoric acid applied in large doses as raw phosphate rock to last four crops be more profitable than an equal money value of phosphoric acid as reverted phosphate one-fourth applied with each of the four crops?

(5) What amounts of reverted phosphate are most profitable to apply?

The combined results of the four experiments are negative for the first crop of plant cane. There is no definite response from phosphoric acid when used supplementary to nitrogen applications. The expenditure for phosphoric acid is not returned in an increased yield even when 2712 pounds of reverted phosphate (400 pounds P_2O_5) or 5071 pounds raw rock phosphate (1600 pounds P_2O_5) per acre were applied. While there is no effect of phosphoric acid treatments when used on plant cane in addition to heavy nitrogen applications, we must continue to repeat these experiments on the ratoons and observe the outcome of any residual effect before drawing definite conclusions. Evidence at Pepeekeo* and Honomu† indicated we cannot expect gains from different forms of phosphoric acid, and these results at Hakalau are showing that along the Hilo coast, applications of phosphates are not profitable.

Hakalau Experiment No. 4, 1919 Crop.‡

SUMMARY.

The comparisons here were between the following forms of phosphoric acid (equal amounts of P_2O_5):

(A) Reverted Phosphate (14.73% P_2O_5).

(B) Raw Phosphate Rock (31.55% P_2O_5).

(C) Acid Phosphate (19.00% P_2O_5).

(X) Nothing.

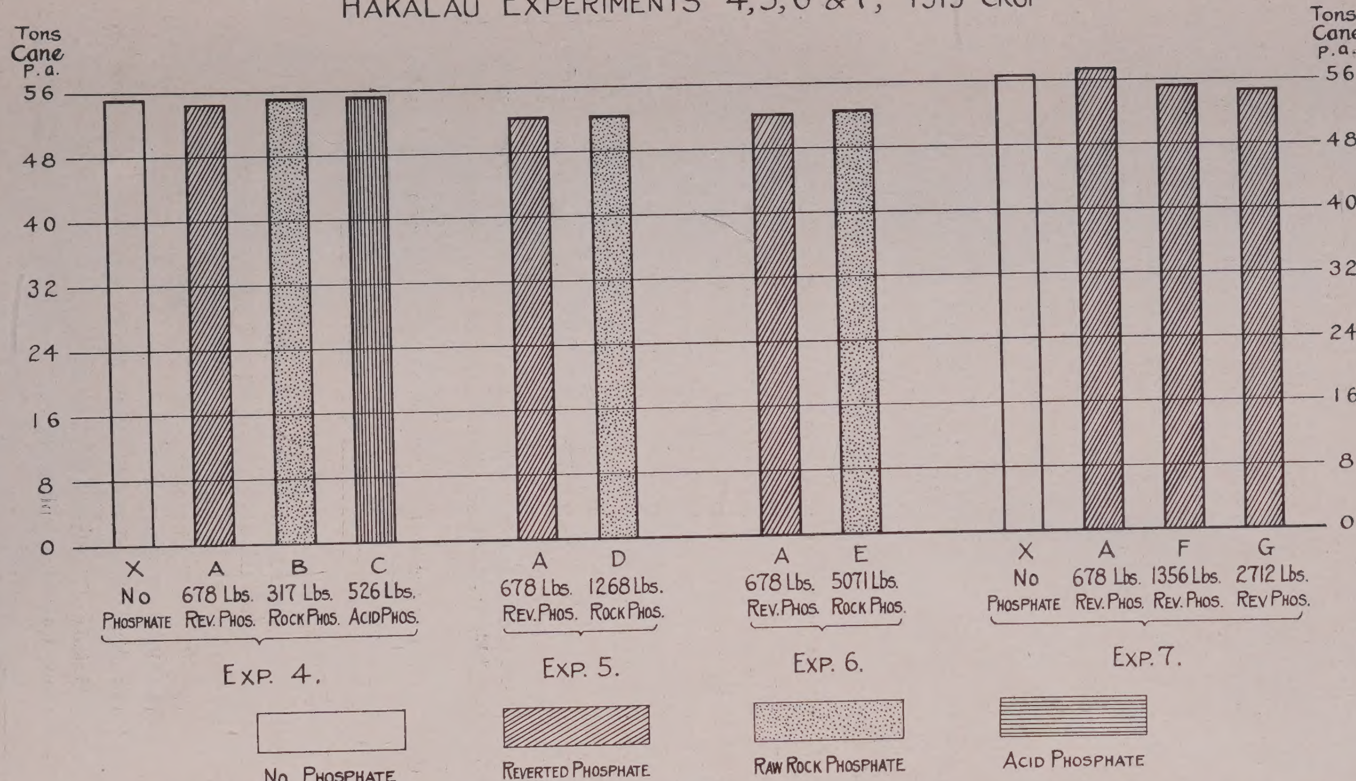
The phosphates were applied in the furrow before planting, and incorporated into the soil with a grubber.

* Reported in **Record,** Vol. XVI, p. 300.

† Reported in **Record,** Vol. XVI, p. 280.

‡ Experiment planned by L. D. Larsen. Experiment laid out by W. P. Alexander and J. S. B. Pratt, Jr.

KINDS AND AMOUNTS OF PHOSPHORIC ACID.
HAKALAU EXPERIMENTS 4, 5, 6 & 7, 1919 CROP



A summary of the results follows:

Plot	No. of Plot	Treatment	Yield per Acre		
			Cane	Q. R.	Sugar
A	8	Reverted Phosphate	54.5	7.94	6.86
B	8	Raw Rock	55.2	8.38	6.59
C	8	Acid Phosphate	55.4	8.03	6.90
X	24	No Phosphate	55.2	8.19	6.74

These results show no difference whatever in the cane yields from the different forms of phosphates as compared to no phosphate. Acid phosphate and reverted phosphate produced slightly more sugar per acre than did the no-phosphate plots on account of having slightly better juices.

Sampling in the field is subject to an experimental error, and until we receive confirmation in other tests it cannot be definitely stated that phosphoric acid will improve the quality of juices.*

Juices analyses were as follows:

Plots	No. of Plots	Juice			Sucrose in Cane	Quality Ratio
		Brix	Sucrose	Purity		
X	1.2 to 1.24	18.9	16.3	86.2	13.62	8.18
X	2.1 to 2.23	18.6	16.2	87.1	13.54	8.19
A	1.1, 1.7, 1.13, 1.19	18.7	16.4	87.7	13.70	8.07
A	2.4, 2.10, 16.2, 2.22	19.5	17.0	87.2	14.20	7.82
B	1.3, 1.9, 1.15, 1.21	18.8	16.1	85.6	13.45	8.32
B	2.6, 2.12, 18.2, 2.24	19.4	16.1	83.0	13.45	8.45
C	1.5, 11.1, 1.17, 1.23	19.2	16.5	85.9	13.79	8.10
C	2.2, 2.8, 14.2, 2.20	19.2	16.7	87.0	13.95	7.96

DETAILS OF EXPERIMENT.

Object.

1. To test the fertilizing value of phosphoric acid in various forms.
2. To compare the following forms of phosphoric acid (equal amounts of P_2O_5), as—
   - (a) Reverted phosphate (14.73% P_2O_5).
   - (b) Raw phosphate rock (31.55% P_2O_5).
   - (c) Acid phosphate (19.00% P_2O_5).

Location—Hakalau Plantation Co., Field 10.

Crop—Yellow Caledonia, plant cane.

---

* No improvement of juices due to P_2O_5 is noted in Paauhau Experiment No. 12 (1919 Crop) and Grove Farm Experiment No. 6, 1919 Crop.

Kinds And Amounts Of Phosphoric Acid.

Hakalau Experiments 4,5,6 & 7, 1919 Crop

	Exp. 4.		Exp. 5.	Exp. 6.	Exp. 7.	
1	A 55.09	X 57.07	A 56.00	E 54.32	F 43.69	X 71.34
2	X 63.21	C 53.80	D 52.05	A 51.91	G 53.51	A 74.50
3	B 57.29	X 51.95	A 53.61	E 54.03	X 51.30	F 73.09
4	X 55.24	A 56.94	D 53.73	A 54.85	A 53.01	G 68.70
5	C 54.32	X 56.77	A 52.59	E 51.97	F 54.60	X 67.79
6	X 54.33	B 57.88	D 54.97	A 52.98	G 49.83	A 69.31
7	A 55.45	X 58.21	A 52.10	E 50.68	A 52.02	F 67.05
8	X 50.17	C 56.51	D 52.13	A 51.40	A 53.08	G 62.24
9	B 49.44	X 50.70	A 48.43	E 51.01	F 52.81	X 63.98
10	X 49.18	A 45.65	D 54.33	A 53.76	G 56.98	A 67.46
11	C 55.74	X 55.96	A 50.08	E 58.77	X 62.41	F 61.68
12	X 57.19	B 54.82	D 48.21	A 55.84	A 53.52	G 61.42
13	A 58.58	X 57.52	A 43.51	E 52.68	F 52.71	X 59.07
14	X 61.12	C 54.57	D 47.88	A 53.76	G 49.14	A 54.36
15	B 65.68	X 57.29	A 55.14	E 53.78	X 50.49	F 48.98
16	X 58.30	A 57.77	D 49.11	A 50.38	A 51.28	G 49.17
17	C 60.70	X 52.82	A 52.47	E 54.56	F 48.45	X 49.82
18	X 56.55	B 50.28	D 50.88	A 47.51	G 47.98	A 48.75
19	A 55.61	X 55.72	A 54.57	E 50.98	X 55.60	F 48.81
20	X 58.47	C 56.00	D 56.87	A 55.66	A 57.19	G 49.29
21	B 56.51	X 54.61	A 55.46	E 50.21	F 55.05	X 50.33
22	X 56.70	A 50.68	D 55.54	A 52.77	G 54.54	A 53.62
23	C 51.81	X 49.09	A 54.47	E 47.45	X 45.69	F 55.30
24	X 48.98	B 49.85	D 52.77	A 48.32	A 51.80	G 51.03

Summary Of Results

Plot	Treatment	Yield Per Acre Cane	Q.R.	Sugar
A	678* Rev. Phos.	54.47	7.94	6.86
B	317* Rock Phos.	55.22	8.38	6.59
C	526* Acid Phos.	55.43	8.03	6.90
X	No Phosphate	55.20	8.19	6.74

Summary Of Results

Plot	Treatment	Yield Per Acre Cane	Q.R.	Sugar
A	678* Rev. Phos.	52.37	7.88	6.65
D	1268* Rock Phos.	52.37	7.90	6.63

Summary Of Results

Plot	Treatment	Yield Per Acre Cane	Q.R.	Sugar
A	678* Rev. Phos.	52.43	7.93	6.61
E	5071* Rock Phos.	52.54	7.94	6.62

Summary Of Results

Plot	Treatment	Yield Per Acre Cane	Q.R.	Sugar
X	No Phosphate	56.65	7.67	7.39
A	678* Rev. Phos.	57.32	7.52	7.62
F	1356* Rev. Phos.	55.19	7.66	7.20
G	2712* Rev. Phos.	54.49	7.57	7.20

Layout.

No. of plots = 48.

Size of plots = 1/10 acre, consisting of 6 lines, each line 5.65 ft. wide and 128.3 ft. long.

Plan.

Plot	No. of Plots	Phosphate, Lbs per Acre*	Lbs. P_2O_5 per Acre
A	8	678 reverted phosphate (14.73%)	100
B	8	317 raw rock (31.55%)	100
C	8	526 acid phosphate (19%)	100
X	24	0	0

* Applied in furrow before planting.

Fertilization—Nitrogenous dressing (nitrate of soda).

	July 1, 1917	Sept. 1, 1917	Jan. 15, 1918	April 15, 1918	Tl. Nitrogen
All Plots ..	300 lbs. N. S.	300 lbs. N. S.	300 lbs. N. S.	300 lbs. N. S.	186

Hakalau Experiments Nos. 5 and 6† (1919 Crop).

SUMMARY.

These two experiments, dealing with a trial of reverted and raw rock phosphate, are closely related, and the results are summarized together.

In Experiment No. 5 we compare the value of phosphoric acid applied in equal money values of reverted and raw phosphate rock.

The results are as follows:

Plot	No. of Plots	Treatment	Lbs. P_2O_5	Yields per Acre		
				Cane	Q. R.	Sugar
A	12	678 lbs. rev. phos.	100	52.369	7.88	6.646
D	12	1268 lbs. raw rock phos.	400	52.373	7.90	6.629

In Experiment No. 6 we compare the value of phosphoric acid applied in one large dose as raw rock phosphate to last four crops, with an equal money value of phosphoric acid as reverted phosphate, one-fourth applied with each four crops. The results are as follows:

Plot	No. of Plots	Treatment	Lbs. P_2O_5	Yields per Acre		
				Cane	Q. R.	Sugar
A	12	678 lbs. rev. phos.	100	52.428	7.93	6.611
E	12	5071 lbs. raw rock phos.	1600	52.537	7.94	6.616

† Experiment planned by L. D. Larsen.
" laid out by W. P. Alexander and J. S. B. Pratt, Jr.

The conclusions drawn from the above are: That during one crop of plant cane we cannot expect gains from large quantities of raw rock phosphate. The average of the cane yields for the twelve plots of each treatment is identical, and since reverted phosphate (A plots) gave no increased yields in Experiment 1, it is evident that raw rock phosphate, as well as reverted phosphate, was of no benefit to the cane.

DETAILED ACCOUNT.

EXPERIMENT NO. 5.

Object—To compare equal money values of reverted phosphate and raw rock phosphate.

Location—Hakalau Sugar Co., Field 10.

Layout.

No. of plots = 24.

Size of plots = 1/10 acre, consisting of 6 lines, each 5.65 ft. wide and 128.3 ft. long.

Crop—Yellow Caledonia, plant.

Plan.

Plot	No. of Plots	Lbs. Phosphate per Acre*	Lbs. P_2O_5 per Acre
A	12	678 lbs. reverted phosphate (14.73%)	100
D	12	1268 lbs. raw rock phosphate (31.55%)	400

* Applied in furrow before planting.

Fertilization—Nitrogenous dressing (nitrate of soda).

	July 1, 1917	Sept. 1, 1917	Jan. 15, 1918	April 15, 1918	Tl. Nitrogen
All plots ...	300 lbs. N. S.	300 lbs. N. S.	300 lbs. N. S.	300 lbs. N. S.	186 lbs.

EXPERIMENT NO. 6.

Object—To compare the value of phosphoric acid applied in large doses as raw phosphate rock, to last four crops, with an equal total money value of phosphoric acid as reverted phosphate, one-fourth applied with each of the four crops.

Location—Hakalau Plantation Co., Field 10.

Layout.

No. of plots = 24.

Size of plots = 1/10 acre, consisting of 6 lines, each line 5.65 ft. wide and 128.3 ft. long.

Crop—Yellow Caledonia, plant.

Plan.

Plot	No. of Plots	Phosphate Applied,* Pounds per Acre	Lbs. P_2O_5 per Acre
A	12	678 lbs. reverted phosphate (14.72%) applied with each crop..........	100
E	12	5071 lbs. raw rock phosphate (31.55%) to last for four crops............	1600

* Applied in furrow before planting.

Fertilization—Nitrate of soda.

	July 1, 1917	Sept. 1, 1917	Jan. 15, 1918	Apr. 15, 1918	Tl. Nitrogen
All plots ...	300 lbs. N. S.	300 lbs. N. S.	300 lbs. N. S.	300 lbs. N. S.	186 lbs.

Hakalau Experiment No. 7† (1919 Crop).

SUMMARY.

Different amounts of phosphoric acid—0, 100 pounds, 200 pounds, and 400 pounds—in the form of reverted phosphate, were compared.

The tabulated results follow:

Plot	No. of Plots	Lbs. Rev. Phos. per A.	Lbs. P_2O_5	Yields per Acre		
				Cane	Q. R.	Sugar
X	12	0	0	56.65	7.67	7.39
A	12	678	100	57.32	7.52	7.62
F	12	1356	200	55.19	7.66	7.20
G	12	2712	400	54.49	7.57	7.20

The average yields of cane from twelve plots of each treatment vary slightly, and the differences by plots are too inconsistent to draw definite conclusions. It does appear, however, that supplementary applications of reverted phosphate have not been profitable on the plant crop for conditions at Hakalau Plantation Co.

The quality of juice of the plots receiving 678 pounds of reverted phosphate is better than the no-phosphate plots. This, however, does not hold true for all the reverted phosphate plots. Previously we have had no indication that phosphoric acid will improve the juices.

† Experiment planned by L. D. Larsen.
" laid out by W. P. Alexander and J. S. B. Pratt, Jr.

The detailed juice analysis follows:

Plot	Plot Numbers	Brix	Suc.	Purity	Q. R.
X	5.3, 5.7, 5.11, 5.15, 5.19, 5.23, 6.1, 6.9, 6.13, 6.17, 6.21	19.6	17.2	87.8	7.71
A	5.4, 5.8, 5.12, 5.16, 5.20, 6.22, 5.24, 6.2, 6.6, 6.10, 6.14, 6.18	20.1	17.6	87.6	7.54
F	5.1, 5.5, 5.9, 5.13, 5.17, 5.21, 6.3, 6.7, 6.11, 6.15, 6.19, 6.23	19.7	17.3	87.8	7.66
G	5.2, 5.6, 5.10, 5.14, 5.18, 5.22, 6.4, 6.8, 6.12, 6.16, 6.20, 6.24	19.9	17.5	87.9	7.58

DETAILS OF EXPERIMENT.

Object—To compare different amounts of reverted phosphate.

Location—Hakalau Sugar Co., Field 10.

Layout.

No. of plots = 48.

Size of plots = 1/10 acre, consisting of 6 lines, each line 5.65 ft. wide and 128.3 ft. long.

Crop—Yellow Caledonia, plant cane.

Plan.

Plots	No. of Plots	Lbs. Reverted Phosphate per Acre*	Lbs. P_2O_5 per Acre
A	12	678	100
F	12	1356	200
G	12	2712	400
X	12	0	0

* Applied in furrow before planting.

Fertilization—Nitrogenous dressing (nitrate of soda).

	July 1, 1917	Sept. 1, 1917	Jan. 15, 1918	Apr. 15, 1918	Tl. Nitrogen
All plots ...	300 lbs. N. S.	300 lbs. N. S.	300 lbs. N. S.	300 lbs. N. S.	186 lbs.

Progress Notes for Experiments 4, 5, 6 and 7.

May 29, 1917—Phosphates applied in furrow. Incorporated into soil with grubber.

June 1, 1917—Field planted with Yellow Caledonia.

July 2, 1917—Nitrate of soda applied uniformly at the rate of 300 lbs. per acre.

July 27, 1917—No difference between plots. Cane in good condition. An excellent stand and healthy green color.

August 13, 1917—View from plot boundaries and small knoll in upper part of field no difference in growth or color observed.

October 4, 1917—Nitrate of soda applied uniformly at the rate of 300 pounds per acre.

February 5, 1918—Nitate of soda applied uniformly at the rate of 300 pounds per acre.

May 20, 1918—Nitrate of soda applied uniformly at the rate of 300 pounds per acre.

May 7-June 12, 1919—Experiments harvested. Composite samples from plots of same treatment run through the first mill each day. Analysis made by Mr. Raymond Elliot.

W. P. A.

Reverted Phosphate at Paauhau.

PAAUHAU EXPERIMENT NO. 12, 1919 CROP.†

The value of applying reverted phosphate in the furrow before planting was tried in this experiment at Paauhau. The phosphate was applied by hand and mixed into the soil by means of a horse cultivator, after which the cane, Yellow Caledonia, was planted.

The experiment consisted of three sets of plots for the phosphate treatment; in addition a supplementary application of lime was used on some plots.

The plan of the experiment was as follows:

Plots	No. of Plots	Treatment
X	16	No reverted phosphate
A	8	750 lbs. reverted phosphate per acre
B	8	1500 lbs. reverted phosphate per acre

In addition to the above, four X plots (Nos. 2, 6, 9 and 13) received 168 pounds of lime per acre to compensate for the lime content of the reverted phosphate added to the A plots. Double that amount of lime was added to X plots 4, 8, 11 and 15 to correspond to the lime in the phosphate added to the B plots.* Previous to this supplementary lime application the whole field had received hydrated lime at the rate of one ton per acre.

This lime was added to determine the value of the phosphoric acid itself, that is, of P_2O_5, as well as in the form of reverted phosphate.

The results of the harvest are given as follows:

Treatment	Yield per Acre		
	Cane	Q. R.	Sugar
No reverted phosphate	36.9	8.01	4.61
750 lbs. reverted phosphate......	38.8	8.09	4.79
1500 lbs. reverted phosphate......	38.7	8.04	4.81

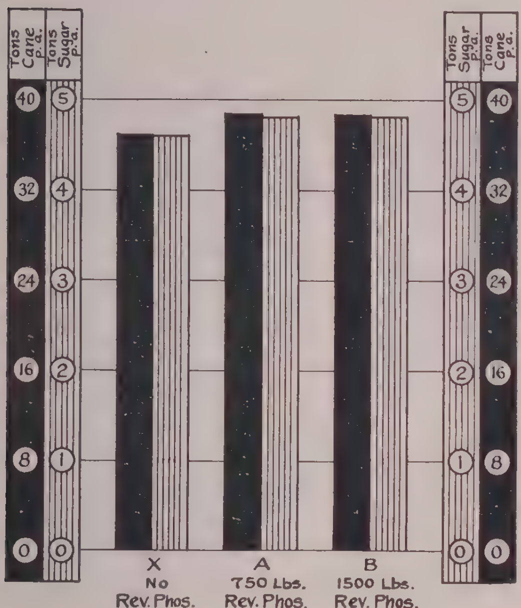
These figures indicate a gain of 2 tons of cane and 0.20 ton of sugar in favor of the reverted phosphate. This gain is small, and the individual plot yields do not indicate this gain to be as consistent as it might be, although the majority of the phosphate plots show gains over the no-phosphate plots. Unless this gain is kept up in the ratoon crops without further addition of phosphoric

† Experiment planned by L. D. Larsen and W. P. Alexander.
" laid out by W. P. Alexander and J. S. B. Pratt, Jr.

* These figures were evidently based on a mono-calcium phosphate, and not a "di." The probability is that more lime was contained in the phosphates than was applied to the X plots.

Reverted Phosphate Experiment

Paauhau Sugar Plantation Co. Exp. 12, 1919 crop



acid, the profit will be rather small. It is planned to repeat this experiment to determine if there is to be any residual effect.

The results of the supplementary lime application to some of the X plots are given below:

Treatment	No. of Plots	Yield per Acre		
		Cane	Q. R.	Sugar
No extra lime	8	37.8	8.08	4.67
168 lbs. lime per acre	4	36.0	8.00	4.50
336 lbs. lime per acre	4	36.2	7.82	4.62

In the table on the following page are given the yields of the lime and no-lime plots when compared to the phosphate plots immediately adjoining them. This gives a better comparison, as soil variations are to a larger extent overcome when adjoinnig plots only are compared.

Treatment	Yield per Acre			Gain of Phos. Plots Over Adjoining Treatments	
	Cane	Q. R.	Sugar	Cane	Sugar
No extra lime, no phosphate..	37.8	8.08	4.67	...	...
Adjoining phosphate plots....	39.3	8.19	4.80	*1.5	*0.13
168 lbs, lime, no phosphate...	36.0	8.00	4.50	...	...
Adjoining phosphate plots....	37.8	7.94	4.76	*1.8	*0.26
334 lbs. lime, no phosphate...	36.1	7.82	4.62	...	...
Adjoining phosphate plots....	38.6	7.94	4.85	*2.5	0.23

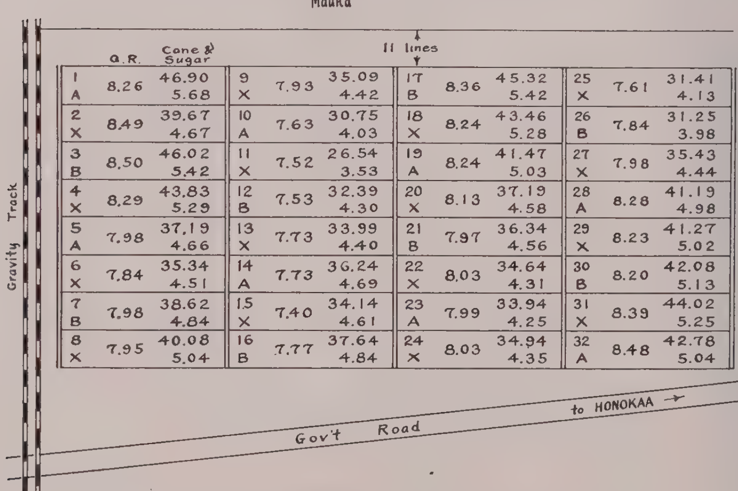
The gains indicated in the above table are all small but consistent in favor of the plots receiving phosphate. But there is nothing in the above table to lead us to believe that the added lime to some of the X plots was of any value in increasing the yields of cane.

Strange as it may seem, we have not of recent years harvested an experiment which showed a gain when liming an acid soil. We have obtained gains on Oahu with Lahaina and H 109 when liming neutral soils. This question of lime will be gone into more fully when reporting some of our lime experiments.

Reverted Phosphate Experiment

Paauhau Sugar Plantation Co. Exp. 12, 1919 Crop

Mauka



Summary of Results

Plots	No. of Plots	Treatment	Yield Per Acre		
			Cane	Q.R.	Sugar
X	16	No Reverted Phosphate	36.94	8.01	4.61
A	8	750* Reverted Phosphate	38.81	8.09	4.80
B	8	1500* Reverted Phosphate	38.71	8.04	4.81

DETAILS OF EXPERIMENT.

Object.

1. To determine the value of reverted phosphate on acid soils in the Hamakua district.

2. To compare 0, 750 and 1500 pounds reverted phosphate per acre.

Location.

Paauhau Sugar Co., Field 3, on the mauka side of the Government road and on the Honokaa side of the gravity. The area includes that of Experiment No. 1, 1917 Crop.

Crop.

Yellow Caledonia, plant cane.

Layout.

No. of plots = 32.

Size of plots = ¼ acre, each plot consisting of 10 lines, 5 ft. wide and 217.8 ft. long (220.8 ft. from center of path to center of path).

Plan.

Plots	No. of Plots	Lbs. Reverted* Phosphate per Acre
X	16	0
A	8	750
B	8	1500

* Reverted phosphate applied in the furrow before planting and mixed with the soil.

X plots (2, 6, 9 and 13) received hydrated lime at the rate of 168 pounds per acre to compensate for the additional lime applied with the reverted phosphate in the A plots. X plots (4, 8, 11 and 15) received hydrated lime at the rate of 336 pounds per acre to compensate for the additional lime applied with the reverted phosphate in the B plots.

Fertilization—Uniform

POUNDS PER ACRE.

	Sept. 15, 1917	Nov. 15, 1917	May 15, 1918
All Plots	200 lbs. Nit. Soda	400 lbs. Nit. Soda	500 lbs. Nit. Soda

Summary of Work.

March 28, 1917—One ton hydrate lime per acre applied.
April 4, 1917—Experiment laid out.
April 11-12, 1917—Reverted phosphate applied.
April 19, 1917—Hydrated lime applied to one-half of X plots.
April 20, 1917—Experiment planted with Yellow Caledonia.

May 14, 1917—Experiment staked.

September, 1917—Nitrate soda applied, 200 pounds per acre.

November, 1917—Nitrate soda applied, 400 pounds per acre.

May, 1918—Nitrate soda applied, 500 pounds per acre.

May 14-15, 1919—Experiment harvested.

In harvesting, the cane was flumed by plots into separate cars and the cars weighed. The juices were sampled at the crusher as the different cars went through, and averages obtained for each different treatment.

The sampling was done by Mr. Westly, chemist of Paauhau Sugar Plantation Co.

J. A. V.

Reverted Phosphate at Grove Farm.

Grove Farm Experiment No. 6, 1919 Crop.*

This was an experiment testing the value of reverted phosphate as a fertilizer for Yellow Caledonia, first ratoons, under Grove Farm conditions. The experiment consisted of 20 plots of unequal size (approximately 0.3 acre each).

The plan of the experiment was as follows:

Plots	No. of Plots	Treatment
X	7	No reverted phosphate
A	6	750 lbs. reverted phosphate
B	7	1500 lbs. reverted phosphate

The results of the harvest are given in the following table:

Treatment	Yield per Acre		
	Cane	Q. R.	Sugar
No reverted phosphate	40.8	7.95	5.13
750 lbs. reverted phosphate..	42.1	8.20	5.13
1500 lbs. reverted phosphate..	40.1	8.02	5.00

From this table we see that the yields are identical for all treatments. The phosphate was of no benefit at all in this case.

In considering these results it is well to remember that the agricultural practices at Grove Farm are different from those followed on the other plantations on the Islands. At Grove Farm it is the custom to raise three crops, one plant and two ratoons, after which the field is pastured to cattle for three years.

* Experiment planned by R. S. Thurston and L. D. Larsen.
" " laid out by R. S. Thurston.
" " harvested by J. A. Verret and G. B. Grant.

These fields soon become covered with a heavy growth of vegetation, the majority of which are legumes (sensitive plant, wild crotalaria, etc.). Also, during the period of pasturing the field is plowed and harrowed from two to three times before planting. This buries a large amount of manure and green organic matter.

Under these conditions it becomes easier to understand why the cane shows such lack of response to fertilizing at Grove Farm.

With one exception, which will be noted in a moment, no experiment yet harvested on Grove Farm has shown any distinct profit from fertilizer.

On page 34 of the January *Record* we showed pictures of young Caledonia plant growing in Field 22, Grove Farm (Experiment No. 9, 1920 Crop). These pictures were taken within a few feet of each other. The cane is growing on virgin land, is of the same age, and has received identical treatment except that the cane in Figure I has received no reverted phosphate, while that shown in Figure II has received 500 pounds of reverted phosphate per acre.

These pictures were taken several months ago. The differences are as striking now, or even more so. The cane receiving no phosphate is very yellow and backward, while that having had phosphate is very dark green and healthy, and two or three times as heavy.

Adding nitrogen to either of the two treatments produced no results. The need for this plant crop seems to be for phosphoric acid only.

These two experiments are on the same plantation within two miles of each other. In one case we obtained no results whatever when applying phosphoric acid; in the other case we find phosphoric acid absolutely vital to the success of the crop.

This brings out the extreme importance of conducting field experiments under all conditions which may obtain on the different plantations.

It is very dangerous to attempt to draw conclusions of general application from the results of a few field experiments. The results must be taken to apply only when the conditions are known to be the same. These two experiments on Grove Farm show this very strongly.

DETAILS OF EXPERIMENT.

Grove Farm Experiment No. 6, 1919 Crop.

Object.

1. To determine the value of reverted phosphate to first ratoons at Grove Farm.

2. To determine the amount of reverted phosphate to apply.

Location—Field 4.

Crop—Yellow Caledonia, first ratoons.

Layout.

No. of plots = 20.

Size of plots = Unequal. Each plot is approximately half of a watercourse. The watercourses are straight, but not of uniform width. 300 feet from the

makai boundary, a wire was run across the watercourses. This forms the 10 watercourses into 20 plots.

Plan.

Plots	Plot Nos.	No. of Plots	Lbs. Reverted Phosphate per Acre
X	20, 23, 26, 29, 31, 34, 37	7	0
A	21, 24, 27, 32, 35, 38	6	750
B	22, 25, 28, 30, 33, 36, 39	7	1500

Other fertilization uniform throughout; same as plantation treatment of surrounding cane.

TABLE I.

GROVE FARM EXPERIMENT NO. 6—YIELDS BY PLOTS

Plot	T. C. Net	Area	T. C. P. A.
20 X	12.525	0.324	38.65
21 A	15.140	0.353	42.90
22 B	15.105	0.354	42.67
23 X	15.530	0.358	43.38
24 A	12.825	0.294	43.62
25 B	9.330	0.226	41.29
26 X	10.710	0.261	41.04
27 A	8.570	0.208	41.20
28 B	12.910	0.334	38.66
29 X	13.515	0.318	42.50
30 B	10.655	0.298	35.75
31 X	11.945	0.328	36.41
32 A	14.220	0.351	40.51
33 B	13.725	0.345	39.78
34 X	13.215	0.306	43.18
35 A	11.875	0.297	39.98
36 B	12.630	0.311	40.61
37 X	11.895	0.293	40.60
38 A	15.340	0.346	44.33
39 B	14.340	0.344	41.70

The cane was weighed and sampled in carload lots. Each car was sampled as it went through the mill. The juices were then composited for each treatment each day and a true average taken of all. This work was done by Messrs. Case and Grandhomme.

J. A. V.

No Response from Nitrogen at Grove Farm.*

GROVE FARM EXPERIMENT No. 7, 1919 CROP.†

This was an experiment to test the value of varying amounts of nitrogen from nitrate of soda on Yellow Caledonia, first ratoons, at Grove Farm. Three treatments were tried. One set of plots received no fertilizer at all; another set received 100 pounds of nitrogen from 644 pounds of nitrate of soda, while the last set received 200 pounds of nitrogen from 1288 pounds of nitrate.

Previous to the plant crop this field had the regular Grove Farm treatment of three years' pasturing to cattle, and being plowed at intervals, thereby burying all plant growth and manure.

The results of the harvest are given below:

Treatment	Yield per Acre		
	Cane	Q. R.	Sugar
No fertilizer	41.6	7.81	5.33
644 lbs. N. S. (100 lbs. N.).......	42.9	7.86	5.46
1288 lbs. N. S. (200 lbs. N.).......	41.6	7.85	5.30

We have here no gain whatever from the fertilizer. This goes to confirm other results obtained at Grove Farm.

DETAILS OF EXPERIMENT.

Object.

To determine the amount of fertilizer to apply to ratoons under Grove Farm conditions.

Location—Field 4.

Crop—Yellow Caledonia, first ratoons.

Layout.

No. of plots = 18.

Size of plots = Unequal. Each plot is approximately half a watercourse. The watercourses are straight, but not of uniform width. 300 feet from the makai level ditch, a wire was run across the watercourses. This forms the nine watercourses into 18 plots.

† Experiment planned by R. S. Thurston and L. D. Larsen.
" laid out by R. S. Thurston.
" harvested by J. A. Verret and G. B. Grant.

Plan.

Plots	No. of Plots	Lbs. Nitrogen per Acre
X	6	0
C	6	100
D	6	200

Nitrogen to be obtained from nitrate of soda and to be applied in four equal doses—October, 1917; January 1, 1918; May, 1918; June 1, 1918.

Summary of Work.

September 28, 1917—First fertilization.

November 17, 1917—Experiment staked and wired.

January 14, 1918—Second fertilization.

April 29, 1918—Third fertilization.

July 8, 1918—Fourth fertilization.

May 12-14, 1919—Experiment harvested.

The juices were sampled in carload lots at the Lihue mill, each car being sampled, and juices composited for each treatment each day. A true average was taken from the daily samples. This work was done by Mr. Case, chemist for Grove Farm.

J. A. V.

Fertilizer—Forms of Nitrogen.

GROVE FARM EXPERIMENT NO. 1, 1919 CROP.†

This experiment compares value of (A) inorganic nitrogen in several doses with (B) organic nitrogen, in one dose, and (C) no nitrogen, on first ratoons. Both the A and B plots received a spring dressing of nitrate of soda.

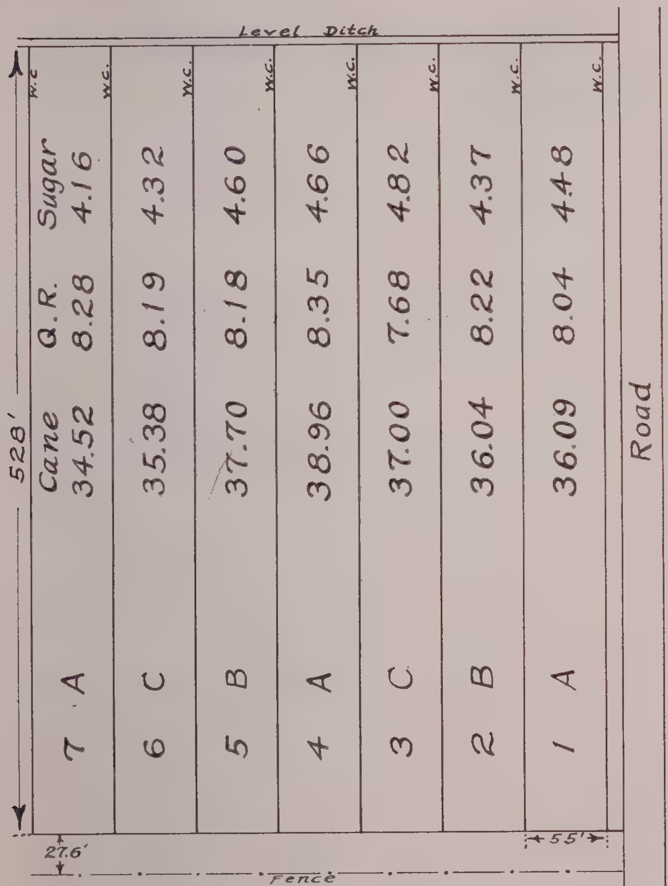
The results of this test show that fertilization has been of no value. The cane yields for the three treatments are practically identical, while the better quality ratio of the no-fertilizer plots gives a slightly better sugar yield than from the fertilizer plots. This difference is well within the limits of experimental error. The yields by treatments are shown in the following table:

Plots	Treatment	Yields per Acre		
		Tons Cane	Q. R.	Tons Sugar
A	Mixed fertilizer	36.5	8.25	4.42
B	Organic	36.9	8.20	4.48
C	No fertilizer	36.2	7.93	4.57

† Experiment planned by R. S. Thurston and L. D. Larsen.

FORMS OF NITROGEN.

GROVE FARM EXPERIMENT I, 1919 CROP
Field #4.



Summary of Results

Plot	Treatment	Yield Per Acre		
		Cane	Q.R.	Sugar
A	Mixed Fertilizer	36.5	8.52	4.42
B	Organic	36.9	8.20	4.48
C	No Fertilizer	36.2	7.93	4.57

The results of this experiment are contrary to expectations, but are substantiated by the results of Grove Farm Experiment 7. All fertilizer experiments heretofore conducted on Grove Farm have been on plant cane* and the lack of benefit from fertilization has been attributed to the Grove Farm system of fallowing. Here, however, we have these two experiments on first ratoon cane which give no response to fertilization.

DETAILED ACCOUNT.

Object.

To compare organic nitrogen with nitrogen from inorganic salts.

Location.

Field 4.

Crop.

Yellow Caledonia, first ratoons.

Layout.

No. of plots = 7.

Size of plots = 2/3 acre (528′x 55′); plots separated by watercourses. Cane lines irregular.

Plan.

Plot	No. of Plots	Form of Nitrogen	Fertilizer in Lbs. Nitrogen per Acre				Total Lbs. Nit. per Acre
			Sept., 1917	Jan., 1918	Mar., 1918	May, '18, as N. S.	
A	3	Inorganic	36.75	36.75	36.75	36.75	141
B	2	Organic	100.25	0	0	30.75	141
C	2	None	0	0	0	0	0

Progress.

July 15, 1917—Trash burned and field palipalied.
September 27, 1917—First fertilization.
January 17, 1918—Second fertilization.
April 29, 1918—Third fertilization.
July 8, 1918—Fourth fertilization.
June, 1919—Experiment harvested by G. B. Grant.

---

* Record, Vol. XVII, No. 2, p. 72.
Record, Vol. XIX, No. 1, p. 270.

Fertilizer Versus No Fertilizer.

Waipio Experiment U, 1919 Crop.

SUMMARY.

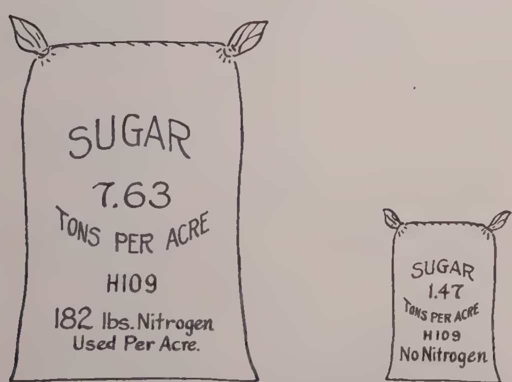
This experiment is to determine the value of varying amounts of fertilizer on two canes, H 109 and D 1135. The fertilization was as follows:

Section	Lbs. Fertilizer per Acre		Total Lbs. Nitrogen
	June, 1918	Sept., 1918	
1	450 lbs. Sulf. Amm.	580 lbs. N. S.	182
3	0	0	0

The results from the averages of the two varieties show that 182 pounds of nitrogen increased the average yield by 5.35 tons sugar over the no fertilizer.

The response of the two varieties of cane to the same fertilization is, however, very different. Both produce about the same amount of sugar with no fertilization, but the increased yields from H 109 by fertilization are greater and continue to increase with larger amounts of fertilizer than with D 1135. We find that 182 pounds of nitrogen increased the yield from H 109 by 6.16 tons sugar over no nitrogen, while the same amount of nitrogen increased the yields from D 1135 by 4.54 tons sugar.

RESULTS OF INCREASED FERTILIZATION.
WAIPIO EXP U, 1919 CROP
Short Ratoons.



The following tabulation shows the yield of averages of both varieties:

Section	Treatment, Tl. Nitrogen	Tons Cane per Acre	Q. R.	Tons Sugar per Acre	Gain Over No Fertilizer
1	182 lbs.	60.05	8.94	6.78	5.35
3	0	12.62	8.82	1.43	0

Fig. 1.

Fig. 2.

The yields of cane from two 1/30-acre plots of D 1135 in Waipio Exp. U (short ratoons). Above (Fig. 1) shows cane from no-fertilizer plot producing 9.83 tons of cane per acre. Lower (Fig. 2) shows the cane from plot receiving 450 lbs. of sulfate of ammonia producing 60.10 tons of cane per acre.

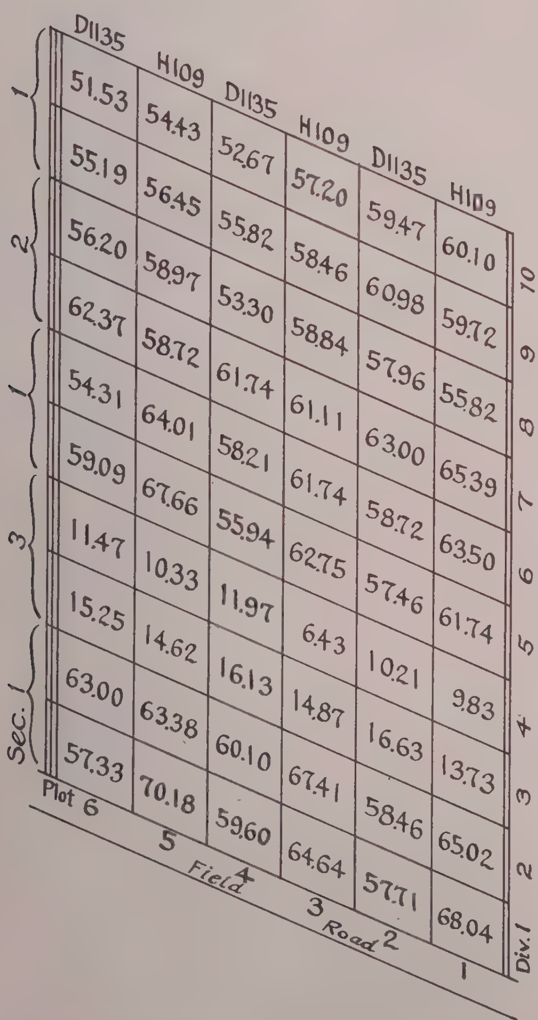
The yields by varieties are shown in the following:

Section	Total Nitrogen	Variety	Tons Cane per Acre	Q. R.	Tons Sugar per Acre	Gain Over No Fertilizer
1	182 lbs.	H 109	62.58	8.20	7.63	6.16
		D 1135	57.53	9.68	5.94	4.54
3	0	H 109	11.63	7.91	1.47	0
		D 1135	13.61	9.74	1.40	0

WAIPIO EXP. U, 1919 CROP

One application and two applications vs. No fertilizer.

(Short Ratoons)



Heavy Fertilization vs. No Fertilization.

Of special note is the fact that the yields of the no-fertilizer plots have been steadily decreasing from crop to crop since 1916, according to the following table:

NO FERTILIZER PLOTS.—AVERAGE YIELDS OF D 1135 AND H 109.

Years.	Tons Sugar per Acre.
1917	2.09
1918	1.80
1919	1.43

DETAILS OF EXPERIMENT.

Amount of Fertilizer.*

Object.

Comparing heavy fertilization with no fertilization.

Location.

Waipio Substation, Section 35.

Layout.

No. of plots = 60.
Size of plots = 1/30.
No. of rows per plot = 8.

Crop.

D 1135 and H 109, third ratoons, short.

Plan.

FERTILIZATION—POUNDS PER ACRE.

Section	June 18, 1918	September 21, 1918
1	450 lbs. Ammonium Sulfate	580 lbs. Nitrate of Soda
2†	450 lbs. Ammonium Sulfate	0
3	0	0

Progress of Work.

March 26-April 2, 1918—Previous crop harvested.
July 18, 1918—First fertilization.
September 21, 1918—Second fertilization.
June 13-18, 1919—Experiment harvested.

† Section 2 received the same fertilizer treatment as Section 1.
* Experiment planned by J. A. Verret.
" harvested by R. M. Allen.

R. S. T. -- W. P. A.

Alkali Studies in Utah.†

Continuing previous work at the Utah Experiment Station, an attempt was made to determine with more exactness the quantities of the various salts that prohibit crop growth under different soil conditions. The general method of procedure was the same as was used previously (E. S. R., 34, p. 125) in studying the effects of different salts and combinations of salts. In these experiments, sodium carbonate and sodium sulfate were used at rates of 500, 1000, 3000, 5000, 7000 and 10,000 parts per million of dry soil, and sodium chlorid at rates of 400, 1000, 2000, 3000 and 4000 parts. Wheat plants were grown in the glass tumblers for 21 days in sand, loam, clay, and garden soil, with and without addition of peat or manure and with varying amounts of moisture. About 12,000 determinations of the effect of the salts on germination and growth under the different conditions were made.

Summarizing the results, it is stated that "size of particles of a sand independent of other factors does not seem appreciably to influence the toxicity of alkali. Loam soils are more tolerant of alkali than either sand or clay. The coarser loams are more tolerant than the finer at the same moisture content, but if the heavier loams are maintained at an equivalent moisture content they are more tolerant.

"Organic matter increases the resistance to alkali when the soil containing it is given sufficient moisture, but where present in large quantities organic matter decreases the resistance if the moisture supply is low. Increasing the moisture content of a soil up to the maximum that will produce good crops increases resistance to alkali.

"The toxicity of sodium chlorid and sodium sulfate seems to depend to quite an extent on the relation between concentration of salt and percentage of moisture present, while the toxicity of sodium carbonate is more largely affected by the presence of organic matter. Organic matter in the soil seems actually to remove sodium carbonate from the soil solution in large quantities. This probably explains why in experiments where sodium carbonate is added to a loam soil, it is less toxic than sodium chlorid, while in field studies where the salt is determined by analyses and in solution and sand culture studies the sodium carbonate is more toxic.

"Practical conclusions that may be drawn from these experiments are: (1) Loam soils and soils with a high water-holding capacity may be successfully farmed at a higher alkali content than others; (2) soils in which alkali reduces crop yields should be kept as moist as is compatible with good plant growth; and, (3) manure, or other organic matter, should be beneficial to alkali soils, especially those high in carbonates." J. A. V.

† F. S. Harris and D. W. Pittman, Jour. Agr. Research (U. S.), 15, 1918.

Yellow Stripe Disease in the Argentine.

Yellow Stripe disease, which has recently caused much concern in Porto Rico, is now known to occur in the Argentine. From a photograph and description of the disease submitted from the Agricultural Experiment Station of Tucuman, Argentine Republic, Dr. Lyon is convinced that the disease is the same as that which we contend with here. An interesting point in connection with the disease in the Argentine and Porto Rico is that it is reported on the cane which is known here as the Striped Mexican variety. Our Striped Mexican is supposedly the same as the striped cane of Louisiana, the West Indies, Cuba and South America, and here this variety is practically immune to Yellow Stripe disease. But this is not the case in other countries, according to the reports from Porto Rico and Tucuman. Mr. G. S. Fawcett, pathologist of the Agricultural Experiment Station at Tucuman, gives the following description of the malady as it occurs there, and accompanies it with the photograph which we reproduce herewith:

"We have here on the 'criolla' varieties, which consist of the Cristallina, the Purple and Striped canes (identical with those of Porto Rico and Louisiana), and other varieties of the same type, a peculiar spotting of the leaves which manifests itself in spots or stripes of varying length, from 1 to 50 mm. or more, the width being variable but generally from 1 to 3 mm. They are not sharply outlined, but merge somewhat with the surrounding green tissue. Their color is pale green of varying degrees of intensity, to white or yellowish. In the recently sprouted leaves the tendency to the spotting is manifested by elongated, irregular blotches, of varying shades of green; in short, a sort of mosaic effect. The spots often merge, and in the badly affected, older leaves, give the plant a decidedly light color. The general appearance of the affected leaves is the same as that shown in the photographs accompanying articles by Mr. John A. Stevensen, of Porto Rico, in his articles in various periodicals on 'a new disease of cane,' e. g., 'La Enfermedad Nueva de la Cana' in *Revista de Agricultura de Puerto Rico,* Vol. 1, April and May, 1918, but it differs somewhat in that the stalks of the affected plants do not show the spots or cankers that accompany this disease in Porto Rico.

"The spotting in question has been known here for years. Its effects on the cane must be unfavorable. The varieties most affected are not grown here now to any extent, although they were formerly the principal canes."

[H. P. A.]

AN IMMUNE VARIETY OF SUGAR CANE.

By C. O. Townsend.*

Several years ago a serious disease of sugar cane appeared in Porto Rico. Owing to certain characters exhibited by this disease it was designated as the mottling disease of sugar cane (sometimes called mosaic). It may be identical

* U. S. Dept. of Agriculture.

Photograph of cane leaves affected with Yellow Stripe disease, submitted by the Agricultural Experiment Station of Tucuman, Argentine.

with the yellow stripe disease prevalent in Java and some other cane countries. At the request of the Porto Rican authorities the U. S. Department of Agriculture entered into cooperation with the insular and federal stations on the island, and Professor F. S. Earle, of the Office of Sugar-Plant Investigations, Bureau of Plant Industry, was detailed to take up the cooperative work in Porto Rico in August, 1918.

Among other lines of investigation Professor Earle studied very closely the sugar cane varieties growing in Porto Rico. He noted that among about twenty varieties growing at the federal station at Mayaguez there was one Japanese variety (Kavangire) that showed no sign of the mottling diseases, while all the other varieties there were more or less seriously affected. In order to carry this study further, Professor Earle, through the kind cooperation of Russell & Co., inaugurated an experiment with ninety varieties of cane on their Santa Rita Estate. These varieties were planted and grown under the personal supervision of Russell & Co.'s cane-planting expert, Mr. H. Bourne of Barbados. Single rows of cane were planted of the varieties to be tested, and every third row was planted with diseased seed of the Rayada variety (ribbon cane). In this way each variety was uniformly and completely exposed to the infection.

The first planting of the ninety was made on October 1, 1918. Two and one-half months later Mr. Bourne reported that all of the varieties except the Kavangire showed the mottling disease, the infection running from 9 per cent to 96 per cent. This variety has remained free from disease to date (March, 1919), and shows every indication thus far of being immune to the mottling disease.

On January 29 of this year Professor Earle made a careful study of the experiment and found about half of the other varieties in this experiment showing an infection of fully 100 per cent, and in only two cases was it as low as 50 per cent. The degree of infection, however, was decidedly marked in different varieties, a few of them showing the disease but slightly, indicating that they are resistant though not immune, with the exception of the one variety Kavangire, which appears to be entirely immune. In three or four of the least infected kinds close observation is necessary to detect the disease, the only evidence being very faint "watered silk" discolorations. Professor Earle has observed the Kavangire fully matured on the federal station at Mayaguez and in other localities, and in all of the localities in Porto Rico where it is growing it is entirely free from the mottling disease, whether the plants are young shoots or mature canes.

The Kavangire cane is tall-growing and very slender, while the Porto Rican planter prefers a thick cane, because it appears to be a better yielder and is handled at less expense. However, the yield of the Kavangire under some conditions at least compares favorably with other varieties, and very greatly exceeding them in some cases. Director May reports a yield at the rate of 70 tons per acre on the Mayaguez plot. No analyses of the Kavangire variety, as grown in Porto Rico, are available, but, according to some reports from other countries where it is grown, it varies from 14.38 per cent sucrose to 16.85 per cent sucrose, while its purity coefficient varies from 84.6 to 89.67.

The Kavangire cane was imported into Porto Rico from the Argentine a

few years ago by Mr. May, director of the Federal Experiment Station at Mayaguez. In Argentine it has been planted quite largely on a commercial scale, indicating that it is satisfactory from the standpoint of sugar production. It requires a long season for maturity, and for this reason has not been recommended for general planting in Argentina. The sugar per acre is the crucial test, and in this respect the Kavangire generally stands near the top, so far as available records indicate.

After reviewing the available literature in regard to Kavangire, Professor Earle raises the practical question as to whether or not Kavangire can be successfully used for general planting in Porto Rico. If it can, and it retains its immune characteristic, the question of combating the mottling disease is solved. This question of the practicability of using the Kavangire is now under consideration by Professor Earle and his co-workers in Porto Rico, and at the same time further observations will be made upon the immunity of this variety to the mottling disease. Unfortunately, the available supply of plant cane of Kavangire in Porto Rico is limited. It will take a number of years to propagate enough of this variety to make it available for general planting. In the meantime its adaptability to the Porto Rican climatic and labor conditions will be determined. It appears to be a stronger ratooner and to have considerable resistance to root disease, borer and stem rot. If these indications prove true Kavangire should enable the grower to keep his fields in profitable production longer without replanting than is possible with the varieties now in general use. This will reduce the cost of production, even though the habit of growth and quality of the cane should make it a somewhat more expensive variety to handle and to mill.

A Method for Boiling Sugar.

R. C. Pitcairn.*

The first consideration is the mechanical arrangement of the pan floor, and how much time is available for boiling the low-grade massecuite, in order to obtain the most economical results. For this reason, each boiling-house should be considered separately. In these notes I am simply going to outline a method that will handle an ordinary 1000-ton cane plant arranged with one low-grade and two high-grade pans, particularly when it is desirable to use the sugar made in the low-grade pan as a seed for the high-grade or 96° sugar. The most important factors in boiling a low-grade pan are:

First—The evenness in which the original grain is formed.

Second—The concentration or finishing point at which the pan is dropped.

Third—The temperature at which the pan is carried.

Fourth—The purity at which pan is grained, carried and dropped.

In these notes I am going to describe a method I found very simple, and

* Chemist, Wailuku Sugar Co.

give the reasons why I believe boiling sugar is, to a great extent, purely a mechanical operation and should be so regarded and made as nearly fool-proof and mechanical as possible.

First, the ultimate size of the grain of the 96 sugar should be considered in the formation of the grain of the low-grade massecuite. The latter grain must be even so as to purge well, and of sufficient size to be caught by the centrifugal screen. The smaller the grain that can be so caught, the more crystal surface will be brought into contact with the surrounding liquor in boiling. The longer this boiling is continued and this form of crystallization in motion takes place under these conditions, the lower the resultant molasses will be, especially if, just previous to dropping the massecuite, it is carried to a high degree of concentration. I have found the following method very simple in getting an even grain and a low resultant molasses.

As an example, if it is decided that it is most economical to handle the boiling-house with two grades of massecuite, the purity of the first massecuite can be carried at, say, 72 to 73. This will give a good 96 sugar with the use of very little wash water. The resultant molasses from this should be in the neighborhood of 48 to 50 purity.

Now, in an ordinary pan, say nine feet high, approximately a foot and a half to two feet of concentrated molasses of 50 purity or molasses of 50 and melted sugar of a high purity, half and half, or molasses with syrup can be taken in sufficient quantity to give, when concentrated, the desired footing of a foot and a half to two feet in which to form the original grain that is to be the seed for 96 sugar for the market. It should be so figured that the resultant low-grade massecuite purity should be around 50 if possible, as it is possible to get from this, if the pan work has been good, at least 30 apparent purity molasses. Owing to different arrangements of the pan in different mills, it is often desirable to boil first a low-grade seed massecuite, of which part can be taken and used as a footing for another low-grade pan. This can be built up and completed by the addition of molasses, in which case the low-grade seed massecuite can be formed at 52 to 54 purity or even higher, the additional molasses used to complete the massecuite reducing the purity to around 50.

In graining after the first footing has become concentrated to a point at which the sugar crystals begin to appear, or just before this point, if the steam is shut off the grain will immediately appear evenly and in great multitude. The massecuite will still keep in motion for even three hours and at the same time be slowly cooling and the grain will keep forming and growing evenly. As long as the pan is in motion the grain will continue to take up sugar from the mother liquor. (I think this is the same result as is obtained by the so-called graining with white sugar. In this method, a small amount of fine granulated white sugar that has been put through an 80 to 100-mesh screen, about a quart to a thirty-five-ton pan, is taken in by vacuum at about the time the footing is ready to grain. The pan is then stopped and the grain comes in evenly.) The size of these crystals depends upon the original purity and size of the footing. A larger footing, as a blank pan, will give smaller crystals. The grain can then be further enlarged by starting the steam, putting the massecuite in motion and drawing in

a few drinks of water of sufficient amount to change the concentration of the mother liquor and its relationship to the crystals. After the crystals appear to be of sufficient size (either with the use of water but preferably without), the pan can be built up by intermittent feeds of water and molasses together. The grain will continue to grow until the pan is full.

I strongly believe that, after the pan is grained to a sufficient size and started up, water should never be used alone, as it sets the grain back. Even if it is thought desirable to melt out new grain that should not have formed, it costs money to evaporate water in pans. The molasses, being of approximately 82 to 92 Brix, is too heavy to be assimilated readily. A good system of feeding molasses to the pan is as follows:

A tank located close to the pan having a stirrer, molasses, water and steam connections, can be connected to the low-grade pan and used as a feed tank and the feeding molasses temperature kept at a standard of, say, 134° to 140° F., and at a desired economical Brix, and fed to the pan intermittently. The pan temperature can then be maintained at this pan tank temperature by regulating the vacuum. This arrangement will eliminate a great many chances of false grain forming, and is economical. With the aid of charts and a spindle, it gives a good control and eliminates carelessness.

Regarding the temperature to be carried, I believe 140° a desirable point, cooling slowly to 130° before dropping. Regarding the concentration of the pan, if crystallizers are being used I believe it should be carried to a heavy density and then treated with water later, although the massecuite can be heavily concentrated in the pan and just previous to dropping enough molasses added to reduce this concentration to a desirable purging point. Personally, I believe in concentrating and finishing at approximately 98 to 99 Brix, although this will vary with different varieties of cane. The results are then easier to control, as it does not leave so much to the pan-man. After dropping to crystallizers, treating with water in the crystallizers, and then heating at the centrifugals, or adding hot molasses will help the purging of the massecuite. After the low-grade massecuite has been run through the centrifugal machines, the waste molasses should be about 30 apparent purity and ready to discard.

Regarding the purity of the pan, I will simply say that, in my opinion, the initial purity of the seed footing should be the lowest that will give an even grain in the maximum amount of time at your disposal with an economical use of water and steam or exhaust.

The purity of the pan should be such that it will boil evenly, and that the lower the purity the longer the time required in boiling the strike. Personally I believe the amount of time available is the governing factor controlling a pan purity. Although after a pan purity has been found that will give good results, the longer the pan action takes place, the better will be the final results, other controlling factors being standardized as I have suggested.

The sugar extracted can now be used in the form of a seed or remelt as desired; if as seed for the No. 1 sugar, a desired quantity necessary to give a sufficient size grain when completed can be taken into the high-grade pan and built up with sufficient remelt and syrup to make a massecuite purity 72 to 73 and dropped at a good purging point at 93 to 94 Brix. In case this grain is not

of sufficient size at this point, the pan can be cut and built up again and the desired result will generally be obtained in the form of a good even 96° sugar of fair size.

The above method has, in my opinion, the following advantages:

1. Simplicity and control.
2. Economical use of water.
3. The full number of crystals are formed at graining.
4. The crystals are of moderate and even size.
5. The danger of false grain forming is small.
6. A good yield of sugar results.
7. Conglomerates do not seem to form readily from this grain.
8. A good reduction in the purity of the molasses surrounding the crystals takes place.

Cause of Scarcity of Seeds of the Koa Tree.

By O. H. Swezey.

The koa (*acacia koa*) is one of the most important and best known of the Hawaiian forest trees. It is one of those which are becoming conspicuously diminished in many parts of the forests by the presence of cattle, the trees not being able to survive the disturbed conditions when the undergrowth is fed down by cattle. There are great areas, once covered by fine koa forests, in which the koa has either entirely disappeared, or there are only scattered remnants left.

Among the projects for reafforesting, the koa has been found an easy tree to propagate, plant, and to reproduce a forest where the latter has been absent for a time. A fine example of a planted koa forest is to be seen on the slopes of Sugar Loaf Hill above Makiki Valley, where the Board of Agriculture and Forestry has planted many hundred trees, during a period of several years. The oldest of these, being now about eight years old, are growing rapidly, and producing a flourishing forest cover, and a pleasing sight in good view from parts of Honolulu.

Further plantings are being made, but it is extremely difficult to obtain seeds of the koa at the present time. The trees everywhere blossom profusely, but the growing pods are attacked by the larvae of four different species of Tortricid moths (*Adenoneura rufipennis, Enarmonia walsinghami, Cryptophlebia vulpes* and *C. illepida*). The larvae of these moths devour the young growing seeds, traveling from one to another in order to obtain a sufficiency for their nourishment and growth. Sometimes they reach the neighboring seeds of the same pod by burrowing within the pod, and sometimes they gnaw out of the pod at the place where a seed has been eaten, proceed to the position of another seed, and then burrow in to reach it. Several seeds may be eaten by one larva, the number depending on the size of the growing seeds at the time.

Figure 1 shows a koa twig with pods in which the seeds have been eaten by

Fig. 1.
Koa twig with cluster of pods in which the seeds have been eaten by moth larvae.

these moth larvae. Figure 2 shows a pod on a larger scale. This destruction of the seeds is accomplished so thoroughly that there is hardly a seed allowed to mature.

In 50 pods examined, that were collected at Wailupe May 30, the number of seeds that had been eaten was 349, and there were only 8 which had not been injured, and these were not yet full grown, and would probably have yet been eaten before ripening.

In 52 pods examined, that were collected on a ridge above Waianae June 1, 366 seeds were found to have been eaten, and not one left untouched.

200 pods were examined that were collected on Sugar Loaf Hill June 23, where many of the trees in the young planted forest are bearing a good many pods. In these, 1473 seeds were found to have been eaten, and not one left uninjured.

In 61 pods, collected June 23 in Waikakalaua Gulch, 48 good seeds were found, while 303 had been eaten.

In 33 pods, collected June 28 by the roadside about half way up Nuuanu Valley, 5 uneaten seeds were found as against 275 which had been eaten.

TABULATION OF ABOVE OBSERVATIONS.

Locality	No. of Pods Examined	No. of Seeds Eaten	No. of Uneaten Seeds	% of Sound Seeds
Wailupe Ridge	50	349	8	2.24
Waianae	52	366	0	0
Sugar Loaf	200	1473	0	0
Waikakalaua	61	303	48	13.68
Nuuanu	33	275	5	1.79

These observations demonstrate the difficulty involved in securing the seed of this tree, which is so valuable for planting, and whose propagation depends on the seeds. It is not known whether this state of affairs is only of recent years or whether it was present long before the great destruction of koa forests began. If it was the normal condition in a state of nature, it would seem that there would seldom be a seed for providing new trees to keep a forest going. The three chief ones of these moths are native species which are quite attached to the koa, the same as many others of the native forest trees have particular species of insects which attack their fruits and seeds, and not those of any other trees.

Several native species of hymenopterous parasites are known to attack the larvae of these koa pod moths, but at the present time they are not sufficiently efficient. Possibly at the time when the koa forests were in natural condition these parasites were sufficiently effective as to keep the pest reduced or in check to allow enough koa seeds to be produced, a "balance of nature" being maintained. It is often the case that where the natural conditions are disturbed by the hand of man, or his projects, that the balance of nature is upset and some insects become a serious menace when they were not so previously under normal natural conditions.

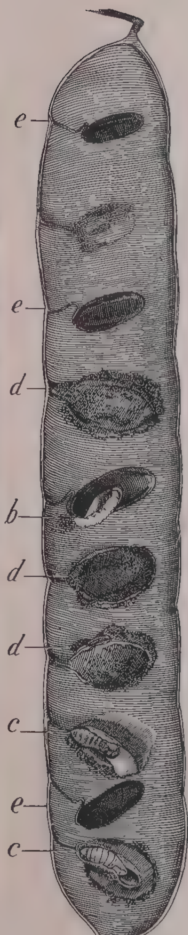


Fig. 2. Fig. 3.

ba pod in which the seeds have been eaten by moth larvae. (Fig. 2.)

The same opened. (Fig 3.)

a. Exit holes where larvae have issued or centered.
b. Larva eating seed.
c. Pupa in situ.
d. Frass, where a larva has eaten a seed.
e. Uninjured seed.

Adenoneura rufipennis. (Fig. 4.)

Enarmonia walsinghami. (Fig. 5.)

Cryptophlebia illepida. (Fig. 6.)

Popilia Japonica, a Serious Pest Recently Introduced Into New Jersey from Japan.

By P. H. Timberlake.

This insect (*Popilia japonica* Newman), which has become known to the New Jersey entomologists as the Japanese beetle, is not greatly unlike our own Japanese rose beetle in appearance and habits, but is more destructive. Its establishment in New Jersey is a distinct menace to agriculture, for unless stamped out in its present restricted range it will unquestionably spread over a greater part of the United States.

Up to the present time it is confined to a relatively small area in Burlington County, New Jersey, and has shown adaptability to its new environment and a tendency to spread with considerable rapidity. The New Jersey State and Federal entomologists are cooperating in an effort to check and finally eradicate the pest before it has spread over too great an area to permit its possible extermination.

The *Popilia* was discovered by Messrs. Dickerson and Weiss in August, 1916, while inspecting a nursery in southern New Jersey, although its identity and its possible menace was not recognized until some months later.* The following summer the same entomologists made an extensive study of its status and found the beetles extremely abundant on weeds near the nursery and spread in one direction for a couple hundred yards. Doubtlessly, however, this was merely the center of distribution and stray beetles must have occurred much further away in the surrounding country. Data on its continued spread during 1917 and 1918 are not at hand, although it has been stated that the infestation is still confined to a comparatively limited area.

Positive information as to how the beetle became established is, of course, not ascertainable, but it is believed by Messrs. Dickerson and Weiss that the insect was introduced in the grub stage in soil around Iris roots from Japan, a few years before its discovery in 1916.

This pest has but one generation per year, and the beetles appear about the last of June and continue to issue from their pupal cells in the soil until August. The females place their eggs in the soil, and the grubs that hatch from the eggs feed on both living roots and decaying vegetable matter during the rest of the summer and fall. During the winter the grubs are hidden away in cells prepared six to twelve inches beneath the surface of the soil, and resume their feeding the following spring. During the latter part of May, June and the first few days of July the grubs become full grown and enter the resting or pupal stage, preparatory to their appearance as adults about a month later.

The *Popilia,* like our own Japanese rose beetle, does the most damage in the adult or beetle stage, but is apparently more voracious, and feeds on the

* Canad. Entom., Vol. 50, July, 1918, pp. 217-221.

foliage of a greater number of plants. The beetles attack various fruit trees, vines and vegetables, such as the apple, peach, grape, raspberry, watermelons, asparagus, sweet potato, lima beans and the ears of corn, and such ornamental trees or shrubs as the rose, Spiraea, holly-hock, ferns, Iris, elm, willows and birch. Among weeds and other wild plants it attacks smartweed, elderberry, milkweed, ragweed, morning-glory, dock, and poison ivy.* This is by no means a complete list of the food-plants in New Jersey that have been recorded, but it will serve to indicate the omnivorous habits of the beetles.

The Federal and State authorities are making a vigorous attempt to suppress and eradicate the pest before it spreads over too large an area. The work was much hampered in 1918 by war activities and a lack of funds, but will be prosecuted more energetically during the present year.

To prevent the spread of the beetles into other parts of the State the following program of work has been proposed for 1919:

(a) The establishment and maintenance of a band one-half mile wide entirely around the infested area, throughout which all non-economic plants attacked by the beetle should be kept covered with a film of poison during the period of flight.

(b) Destruction of all non-economic food-plants of the beetle along the roadsides throughout the infested area, and maintenance of a poisonous coating on all economic food-products along these roadsides.

(c) The removal of farm products from within the infested district to be permitted only during the warm parts of the day, so that the beetles may not attach themselves to the packages or their contents and thus be carried beyond the district. Restriction so far as possible of persons going among infested plants during the evening or early morning so that the beetles may not be carried away on their clothing.

(d) All green sweet corn grain within the infested district to be removed only under quarantine regulations.

The following measures have been proposed for the destruction of the insect within the infested district:

(a) The establishment and maintenance of a poisonous coating on all economic plants attacked by the beetle, and on all economic food-plants which can not be destroyed or otherwise satisfactorily treated, except in certain areas selected to serve as traps and where the beetles are to be collected by hand.

(b) Collection by hand to as large an extent as practicable of the beetles which gather within the trap areas.

(c) Thorough treatment of the soil in the spring and fall with a solution of sodium cyanide in the areas known to be heavily infested with the grubs, so that the number of the latter may be reduced as much as possible.

(d) All cultivated lands to be kept cleanly cultured so that the beetles may not be attracted to them to lay their eggs.

(c) All waste places about cultivated lands to be eliminated to the greatest possible extent, thus reducing the area on which food-plants attractive to the beetles may grow, and in the soil of which they may lay their eggs.

---

* Circular on the Japanese beetle menace, issued by J. J. Davis, Riverton, N. J., April, 1919.

The staff organized to deal with the Japanese beetle menace, and to carry out measures of eradication and suppression, is as follows:

ADVISORY COMMITTEE.

Dr. T. J. Headlee, State Department of Agriculture, New Brunswick, N. J.
Dr. A. L. Quaintance, Bureau of Entomology, Washington, D. C.

FIELD FORCE.

John J. Davis, Joint Agent in Charge of the Japanese beetle project.
W. H. Goodwin, assigned to field insecticidal operations.
Wm. O. Ellis, assigned to life history investigations.
C. H. Hadley, representing the Federal Horticultural Board in the inspection and certification of green sweet corn, and questions of distribution and spread.
John F. Jamieson, assistant, insecticidal field operations.

Entomologists and agriculturists throughout the country will watch the outcome of this work with much interest and concern. The *Popilia* is of especial concern to the people of Hawaii, as it is especially liable to be introduced here

Fig. 1.
Popilia japonica, adult beetle.

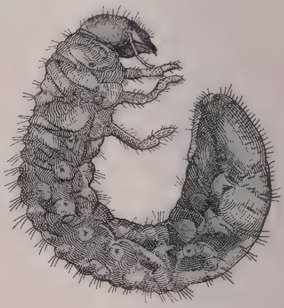


Fig. 2.
Popilia japonica, grub.

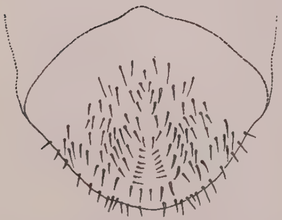


Fig. 3.
Popilia japonica, ventral side of last segment of grub.

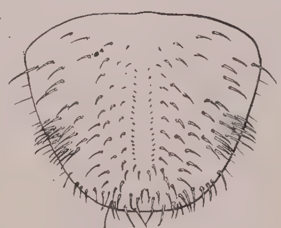


Fig. 4.
Anomala orientalis, ventral side of last segment of grub.

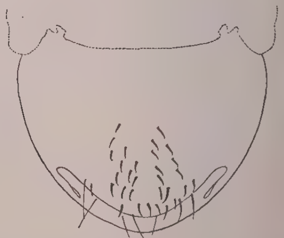


Fig. 5.
Adoretus, ventral side of last segment of grub.

at any time from Japan, and if not intercepted at quarantine could easily become established.

The beetle of *Popilia* is represented in Figure 1, and the grub in Figure 2. The ventral side of the last segment of the grub is given in Figure 3, showing the arrangement of the hairs. For the sake of comparison the same part of the grubs of *Anomala* and *Adoretus* is represented in Figures 4 and 5, respectively.

Notes on Sugar Cane Culture in Java.

By H. L. Lyon.

WITH CORRECTIONS AND ADDITIONS BY H. F. K. DOUGLAS.

Long before the white man became actively interested in the sugar industry in Java, the natives had converted the choicest areas of arable land into well-tilled fields. Such of these lands as could be reached by their irrigation systems were converted into wet rice land or *sawah*. To the Javanese, rice is, and always has been, the staff of life, and in their estimation land was really valuable only when it could produce a good crop of this cereal. Nevertheless, they had from early times cultivated considerable tracts of land which, because of their position or extent, could not be watered from their irrigation canals. These dry lands, called *tegallan,* are suitable at certain seasons for such crops as corn, beans, peanuts, sweet potatoes, and the like.

When white men began to seek lands for cultivation they found two classes of land available—the wild land which had not been previously cleared by the Javanese, and the lands to which the natives had already obtained title through cultivation. The Dutch government assumed and retains absolute title to all the wild lands, but rents them out on perpetual leases (Erfpacht). The lessee pays a nominal rental and is allowed to cultivate the land according to his own ideas, but he must keep it constantly under cultivation or it reverts to the government. On the few sugar estates which have been developed on wild lands, the planters may grow cane year after year on the same fields, a privilege which, as we shall see, is denied the planters who rent their lands from the natives.

My "Notes" were published in the **Record** for September, 1911. When Mr. Douglas visited these Islands a few months ago I asked him to correct these notes and bring them up to date. My original article is here reprinted, with Mr. Douglas' criticism inserted as indented paragraphs following the subject matter to which they refer.—H. L. L.

The Dutch government recognized the titles of the Javanese to the lands which they cultivated, and, furthermore, required them to retain the ownership of these lands. No white man can buy sawah, and he can obtain title to a small tract of land for building purposes only after he has obtained the consent of the government to the transaction.

The rich lowland sawah, under ideal climatic conditions and with its bountiful water supply, offered the most attractive field for the development of sugarcane plantations, and it was on these lands that the sugar industry of Java was inaugurated. A small amount of cane is now grown on some of the better tegallan, and plantations have been developed on the wild lands as already noted; but at the present time Javanese-owned sawah produces the bulk of the island's output of sugar. The sugar planters rent this land from the natives and pay them a substantial rental which is more than they can make off from the land by cultivating rice and other crops.

> The rental for the fields is *not* more than can be made off the land by culturing rice and other crops, but it *is* more than the share of the "landowner," because the natives rarely cultivate their fields without the help of many other natives, who are ordinarily "not landowners," and who earn a living as laborers. The crop is divided in a great number of shares, some larger, some smaller, and the landowner often receives only very few shares of the crop of his land, for many times he has no bullocks to plow the "sawah," and therefore hires animals, plow, labor, etc., from other people against the half or the third of the crop. People who help him during harvesting receive daily a part of the bundles they have cut, etc.

In renting the sawah, and in cultivating it after they have rented it, the planters must comply with hard and fast laws laid down by the government. A sugar company, operating in a given district, is permitted to have only a certain number of acres under cane at any one time, and this acreage does not exceed one-half the total area of the entire district from which they may draw land. The company can rent a piece of land for only eighteen months at a time. During these eighteen months they must prepare the soil, plant the cane, and harvest the crop. At the end of the eighteen months they must return the land to its owners, who in turn are required to cultivate it for eighteen months before they can again rent it to the sugar planters. In the eighteen months during which they cultivate their own lands the Javanese raise four crops; two of rice and two of dry-land crops, such as we have already noted for the tegallan. A rice crop requires six months and a dry crop three months. The natives alternate these crops, putting in a dry crop as soon as the cane is off the land and harvesting their second rice crop just before releasing the land to the cane planters.

> The company in a given district may in total cultivate not more than the number of acres granted in its agreement with the government, and, further, from every "dessa"—that is, a native community—not more than one-third of the registered "sawahs" may be rented for sugar cane. The lease may be for eighteen, and even twenty months. All this is stipulated in a contract which is carefully revised

Fig. 1. Opening up drainage ditches through the sawah. The soil is carried back and spre ad over the field.

and recorded by the government's officers. The crop must be taken off before the time that the field must be prepared for the rice-culture.

When the term of the lease is over, if the cane crop is not yet off, the company can usually get an extension for one month.

The sugar companies take over the sawah, which they are to plant, as soon as the early rice crop has been picked, which is some time in April, and they must release it before the middle of October in the following year. The land which a company took over in April, 1907, they released in October, 1908, and did not get possession of it again until April, 1910. Under this system each piece of land only affords the cane planters a crop every third year, and it is therefore evident that they must divide their available lands into three cropping-series in order to take off a crop every year. You can readily understand the necessity for this arrangement as well as its details if you study the accompanying diagram, Fig. 2, which shows in graphic form the sequence of events on the lands of each cropping-series during a period of five years.

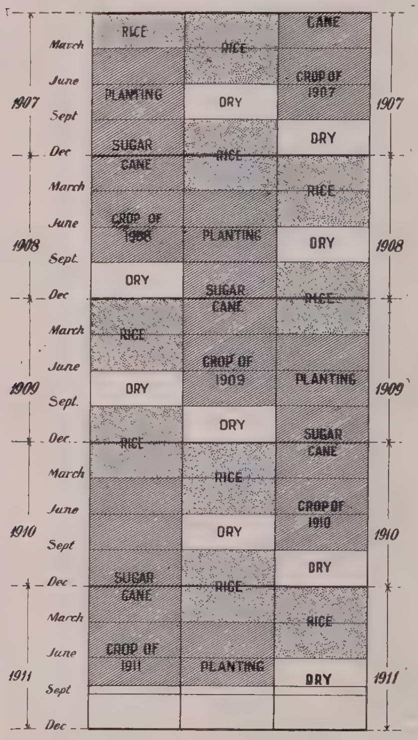


Fig. 2. A diagram to illustrate the sequence of events on the fields of the three cropping series that must be maintained on each sugar estate in Java.

From this diagram we must not infer that they divide their land into three solid sections, for such is very far from the truth. The native holdings are, as a rule, in small blocks, and consequently the sugar planters do not acquire continuous tracts of large extent; but, on the contrary, their fields are usually small and scattered among fields of rice and dry crops, the whole being intersected by numerous permanent ditches, roads and hedges. This isolation of small fields offers no great obstacle to the economical management of a plantation, for all the work in the cane fields—the preparation of the soil, planting, cultivation, irrigation and harvesting—is done by hand.

According to the concession, the company returns to the same field every two or three years, provided the owner has let his piece of land again. If the company returns in two-yearly succession, the owner, upon the return of his land, if the cane crop is taken off early, i. e., from the months of May to September, can cultivate what is called "dry" crops, such as maize, sweet potatoes, peanuts, soya-beans, etc., and later, in December, rice. The company has to wait till the rice crop is taken off, and starts again the preparation for the cane-

Fig. 3. Opening the trenches of the cane rows.

> fields. However, if the company comes back in three years, then the native owner can, if the cane crop is taken off early, have crops of maize, rice, maize and rice. In both events, the owner gets one dry crop less, when the cane crop is harvested very late in the year, around November, because then he has to wait his turn for the preparation of the rice fields.
>
> A crop of rice, to grow and mature, requires between four and six months, inclusive of the forty-five days in the nurseries. It is prohibited to plant a rice variety that demands a longer time for maturing, such as Siam rice.

From various writings on sugar-cane culture in Java we had gathered that the land laws of the country expressly forbade the growing of ratoon cane on account of the prevalence of Sereh; and, furthermore, that these laws prescribed the rotation of crops outlined above as the proper method of coping with this disease. It appears, however, that Sereh really had no influence on the framing of these laws, and, in fact, has not called forth any legal action looking towards its control. The laws were actually framed to protect the interests of the natives by keeping the larger part of the sawah under rice and other native food crops. Java is as densely populated as any agricultural country on the face of the earth. Her population has always consumed just about as much rice as the island produced. If the home crop of this staple was greatly reduced the country would at once feel all the fluctuations of the world's food markets; and in case of a shortage or failure of the rice crop in neighboring countries, there would be a veritable famine in Java. The extensive cultivation of cane on the sawah was therefore a cause for considerable apprehension to those who controlled the destinies of the colony. The growth of the sugar industry obviously necessitated a corresponding decrease in the rice output, and the unlimited development of the former meant the gradual elimination of the latter. The laws governing land tenure, the working of which we have already reviewed, were therefore framed to permit the development of the sugar industry only so far as was possible without seriously depleting the country's supply of home-grown rice. The sequence of events made necessary by these laws was not new to the agriculturists of Java, for the laws merely regulated the recognized methods and practices in a way to accomplish the desired end. That these laws have been a real boon to the Javanese is clearly shown by their exceptionally prosperous condition up to the present time. At the same time the sugar planters prospered and Java early became one of the leading sugar-producing countries of the world.

> There are no laws prescribing a three-year culture. Every company has in its concessions all conditions specified, and in the last decade the government grants only the concession with the condition of a three-year succession, because it is aware that the population has increased, and therefore requires more rice. The laws regarding ratooning were especially made in 1882 when the Sereh disease began, and were supplemented and amended several times afterwards. They were especially made for the culture of sugar cane in those regions where "plant cane"* was cultivated. Thus it is not allowed to ratoon for "plant cane." Nevertheless, the application of these laws is slackened; even ratooning is done now in several places, but I am sure that this is one of the causes of the progress of the "zeefvatenziekte," being, in

* Cane grown for seed, i. e., seed-cane nurseries.

Fig. 4. The row trenches extend from one drainage ditch to the next except for this banks of earth which are left at each end, and narrow channels are cut through these.

> my opinion, the same as "sereh." During the last two years I advocated the stringent application of the laws, and urged the establishing of a cooperative nursery for Stam-cane and a cooperative control on all private nurseries. As to the sugar companies, one of the conditions of their concessions is that new fields be planted every year so that only a few companies which own land in fee simple can ratoon if they wish to do so. I have never seen more than one ratoon, for the cane grows very poorly, and there is no profit.
>
> It is a fact that the government in the last ten years has taken every opportunity to change the old concessions from two-year to three-year concessions, because every year several hundred thousand tons of rice must be imported from Saigon, Rangoon, etc.

In their own agricultural enterprises the Javanese use the primitive methods common to all Oriental countries. They employ horses, bullocks and caribou to pull their wooden plows, harrows and scrapers, but still do the major portion of the work in their fields by hand. They prepare the sawah, plant, transplant, and irrigate their rice in essentially the same manner as these operations are performed by the Chinese in Hawaii. They cultivate the growing rice to some extent in that they walk through the fields and bury the weeds in the mud with their toes. They recognize a value in artificial fertilizers, but are not well informed as to their most scientific application, if we are to judge from the observations made. In the few cases where we actually saw fertilizer being applied to the rice fields, it was being placed in holes driven in the narrow banks between the rice plots. Ammonium sulfate was the fertilizer employed in this operation.

> I never saw the natives use fertilizer on their sawah, but they try to steal it for their maize fields.

In harvesting their rice crop, the Javanese pick the individual heads by hand, one at a time, and leave the straw standing.

When the sugar planters take over the sawah it is still covered with standing rice straw and divided up by the banks which separated the rice plots. As a rule the straw is not cut or burned, but simply buried in the preparation of the soil. The banks are leveled off; but if the field is terraced to any extent, the terraces are allowed to remain.

> The straw of the rice fields is nearly everywhere cut and burnt; nevertheless, a field is never clean, and that which remains is buried under the piles of soil from the rows. It depends altogether on the question of laborers, and on the time that the field is delivered to the company. Sometimes a field is delivered during the latter part of July, or even in the beginning of August, so that only one month remains to prepare the field and plant it. Therefore the company strictly controls the progress of the planting of the rice fields in the rainy Monsoon. It tries to have their future cane fields so classified that the rice fields are planted at the very latest in the end of February.

In laying out a field for cane they first divide it up into narrow strips by digging parallel drainage ditches, two to four feet deep and twenty-four to fifty

Fig. 5. The drainage ditches and row trenches are completed and the field is ready to be drained and the soil exposed to the weather.

feet apart, depending upon the nature of the soil (Fig. 1). In the better and heavier sawah of East Java these ditches are never less than three feet deep and not more than twenty-five feet apart. At Djogjakarta, where the soil is light, fields were visited in which the drainage ditches were only two feet deep and forty feet apart. Secondary drainage ditches are opened up at right angles to the primary ditches at distances of several hundred feet, and these in turn lead into deeper ditches which convey the water away from the fields. The rows in which cane is to be planted are dug at right angles to the primary drainage ditches and extend from one of these ditches to the next except for thin banks of earth which are left at each end of the rows, and narrow channels are cut through these. In preparing the rows they first dig trenches a foot deep, piling the mud on the banks between the rows. These trenches are about twenty inches wide and three and a half feet apart, center to center. The sides are cut straight down and the shovelfuls of wet earth are carefully built up into walls between the rows so that the trenches appear to be two feet deep or more, although they actually extend only a foot below the former level of the sawah. The arrangement of the rows, as well as their relation to the drainage ditches, is well illustrated in the photographs which are reproduced as Figs. 3, 4 and 5.

After the drainage ditches are completed and the row trenches have been opened, the land is allowed to lie for several weeks in order that the soil may become dried out and rendered friable. As soon as the soil has become sufficiently drained and dried they loosen up the earth in the bottoms of the row trenches for a depth of three inches (Fig. 6), and this constitutes the bed in which the cane cuttings will be planted A study of Figs. 5, 6 and 7 will show how in the space of a few weeks' time the compact, saturated soil of the rice fields is converted into well-drained, friable soil suitable for cane. The more usual method of planting throughout Java is to place cuttings crosswise the row in small holes dug in the loose earth in the bottom. The cuttings are placed eighteen inches apart and each one is carefully watered by hand as it is planted. All the details of this operation can be seen in Fig. 7.

The digging of the parallel ditches depends upon the nature of the soil. A wet soil requires ditches 12 feet apart, and from two to three feet deep. Other soils have ditches 24 to 36 feet apart, and from 1 to 2 feet deep. Secondary ditches are opened at distances from 120, 240 or 360 feet, but on dry soil there are no secondary ditches at all. Also, on dry soils the ditches are not made direct from 1 to 2 feet deep, because the natives use in digging large quantities of water. The result is that after the ditches are ready, nearly all ditches are shut again. They are brought to the full size when the rows are ready, and in this way no money is wasted. Nearly all sugar factories use rows 12, 24 or 36 feet long, according to the quality of the soil; longer rows are not good to irrigate, because the plants on both ends get too much water, and those in the midst too little.

The trench bottoms are loosened up from 3 to 9 inches in depth. Some companies plant in the loose soil, others draw the soil up against the walls and plant on the hard soil below. I always have had the best results with the last method, because the roots give a good communication between the water-containing subsoil and the cultivated surface soil, especially in dry seasons.

Fig. 6. The earth in the bottom of the row trenches is loosened up to a depth of three inches and this constitutes the bed in which the cane cuttings will be planted.

The more usual method is to place the cuttings in the direction of the rows, 1 to 1½ feet apart from end to end. Each cutting contains two or three buds, so that the number of buds in a row varies from 24 to 36 per 12 feet. Where the expense per acre for plant-material is very high on account of the different expensive nurseries in the mountains, the quantity of cuttings is carefully controlled. On light soils few buds are required, and on heavy soils more.

The favorite seed cane in Java is obtained from mountain nurseries which have been established in many parts of the island at elevations of two to three thousand feet. At the nurseries in West Java, which were visited by the writer, entire sticks were being shipped to the plantations, there to be cut into seed of the desired length. The cut ends were first dipped in tar, and then the canes were tied up into bundles of convenient size for handling. This mountain-grown seed is said to give rise to sturdier canes than seed taken from the lowlands, and at any rate the resulting canes are always free from Sereh. It was this latter virtue of the mountain-grown seed that first called into existence the mountain nurseries.

While the mountain-grown seed is much preferred by all the planters, not more than fifty per cent of the cane cuttings planted each year come from the mountains. The balance is taken from the fields of the plantations and is mostly tops from canes being harvested. By referring to the diagram, Fig. 2, of the three cropping series which must be maintained on most of the plantations in Java, we will see that when they are cutting cane in series A they will be planting in series B, and when cutting in series B they will be planting in series C. It is an easy matter therefore to take tops from the fields of one series to plant the fields of the next.

Knowing that just now our seed-cane nursery system interests Hawaiian sugar planters very much, I will again explain this system. To get sound cuttings—that means cuttings free from the germs of Sereh or "Zeefvatenziekte"—we first plant at an elevation of 5000 to 6000 feet in a good climate, *"Grandmother-fields."* Here the cane grows very slowly, so that no earlier than after six months, sometimes later, can the cane be harvested for seed. The whole cane is dug out, selected on the roots free from Sereh, and brought to newly-prepared fields, "*Mother-fields*." Here the cuttings grow during six or seven months at an elevation from 2000 to 2500 feet. Harvesting again the whole stalks with the roots, only the sound cane stalks are sent to the "*Daughter* or *Export fields*," which are at 1000 to 1200 feet elevation. Here the cane grows seven to eight months, and after selection and disinfection with tar the cane stalks are "exported" to the plantation for the sugar-cane fields, being planted during the months of May to August, inclusive. Sometimes this export cane from the daughter-field is also used for planting a "lowland-nursery"; usually a field near the factory for seed-cane purposes. It is easy to understand that from an acre of "Grandmother-field" there is obtained finally a large area of cane fields in the estate. For instance:

1 acre grandmother-field gives about five acres mother-field;

1 acre of mother-field gives six to seven acres export-field;

1 acre export-field gives 6 to 8 acres lowland-nursery, or 6 to 8 acres sugar-cane field.

One acre lowland nursery gives 8 to 15 acres sugar-cane field. In other words, if no lowland nursery is used, which is usually preferable,

Fig. 7. Planting cane. The cuttings are placed crosswise the row in small holes dug in the loose earth in the bottom, and each one is carefully watered by hand as it is planted.

an acre grandmother-field will supply 180 to 280 acres of plantation cane-field. A lowland nursery may supply seed for 8 to 15 acres of plantation cane-field, depending upon the method of harvesting employed. When the entire stalk is harvested and converted directly into cuttings, then the proportion is about 1 : 8; but when the method described by Dr. Lyon on this page, Fig. 8, is employed, the proportion may be from 1 : 15.

I found by experiments that if the fields get a small amount of ammonium sulfate before planting, there are almost no dead buds. To give an idea of the cost of different sorts of seed cane, viz., cuttings of the harvested cane, or cuttings derived by the method mentioned above, I give the following prices per picol (15 picols is a short ton): Top ends of the harvested cane per picol, about 60 to 75 cents; cuttings originating from the grandmother-fields, about Fl. 1.50 to Fl. 3 p. pic. (75 cents is 30 cents American currency).

In fields near Djogjakarta I was able to see in operation peculiar methods of planting which I had heard of in these Islands, but had never seen in practice. Cane which was nearly mature was being used for seed. The laborers first went through the field and cut off the tops which were converted into seed in the usual manner. The sticks were allowed to stand unmolested until the upper eyes had grown out into shoots four to twelve inches long. The portions bearing these shoots were then removed from the sticks which were again allowed to stand and produce another crop of shoots which in turn were removed. This process was repeated until the entire sticks were used up or until they refused to produce any more shoots. The shoot-bearing portions, after being removed from the sticks in the field, were carefully cut across through the center of each internode, thus isolating each node with its subtended shoot. These short, sprouted, but rootless cuttings were then set upright in the ground with the upper, cut end exposed (Fig. 8). The leaves were cropped off to reduce transpiration until the roots should have started sufficiently to keep up the water supply in the tissues.

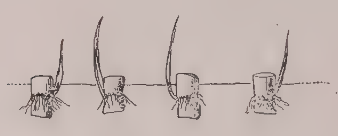


Fig. 8.
A diagram to illustrate the method of planting one-node cuttings, the eyes of which had been started while they were still a part of the standing cane. These cuttings are, of course, rootless when planted.

The cultivation of the soil during the growth of the cane consists essentially of gradually working down the ridges between the rows and drawing the soil up to the cane stools. This is continued until the ground is quite level, and as the cane nears maturity it is actually hilled up to some extent so that twelve to fourteen inches of each stick is buried in the soil. A good idea of the transformation that is wrought in the topography of a field during the growth of a crop can be obtained by comparing Figs. 10, 11 and 12. The continual shifting of the soil annually entails the destruction of all weeds, and Java fields are, as a rule, very clean. The Java planters do not advocate the stripping of their cane as a cultural practice, but they find that in certain cases it is necessary in order to stop the ravages of the stem shield-louse, *Chionaspis madionnensis*. This scale-insect attaches itself to the surface of the internodes and, when numerous, is capable of causing considerable injury to the canes.

Stripping of the dead leaves, as well as the method of application of fertilizers, is a question still in dispute; stripping is sometimes

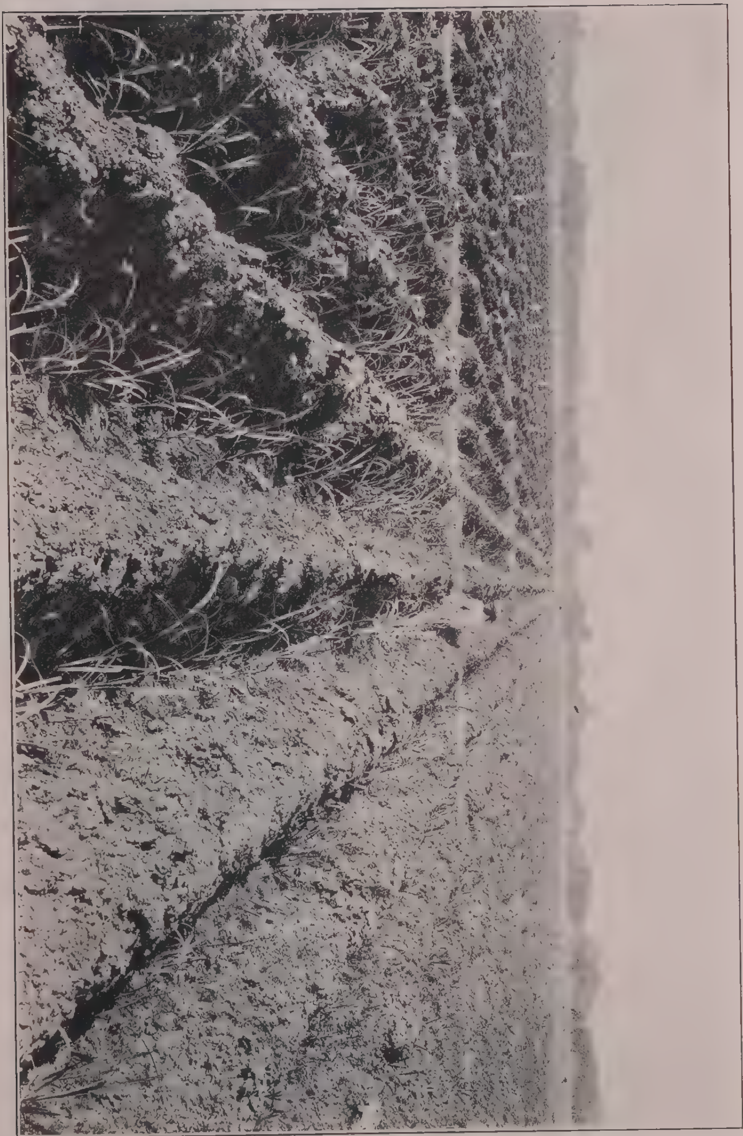


Fig. 9. A field of young cane.

done to prevent the stalks from falling down in heavy rain and wind storms, or to diminish the damage. In such a hot country as Java, with a high humidity, the damage is very large. The percentage of sucrose in the cane decreases from 11% to 5% or 6%, and much cane is rotten, while all germs and fungi find good conditions for spreading.

A cane crop in Java receives two applications of ammonium sulfate and nothing else in the shape of artificial manure. On certain small areas of a peculiar black soil, it is true, they do use some potash and superphosphate in combination with the nitrogenous dressing, but on the more common soils they have found that applications of potash and phosphates give no beneficial results, and so do not include them in their fertilizer. The cane receives its first application of ammonium sulfate as soon as the shoots are well started and their root systems have become established in the soil. The second application is put on about a month or six weeks after the first. The fertilizer is always applied with great accuracy, each stool of cane receiving a uniform dose. In putting on the first application one laborer goes along the row making small holes in the ground at both ends of each cutting. A second laborer follows and carefully pours a spoonful of ammonium sulfate in each hole. A mandoer then inspects the holes to see that the fertilizer actually went into the ground and not into the laborer's clothes, for the Javanese are rather inclined to retain a portion for their own rice fields. If the holes are found to be properly filled another laborer is directed to close them up and the operation is completed. The second application is put on in the same manner except that this time single holes are made equidistant between the stools of cane. The relative positions of the holes in which the fertilizer is placed in the two applications are indicated in Fig. 10.

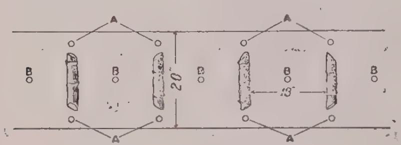


Fig. 10. A diagram to illustrate the method of applying ammonium sulfate to cane in Java. "A" indicates the holes into which the first application is placed, a spoonful in each; and "B" the holes which receive the second dose.

Ammonium sulfate is used everywhere; the method of application differs. It is usually applied in a dry condition. Sometimes it is given as a solution. In dry condition it is put in holes or spread out. At least 2 picols (240 lbs.) per bahoe (1.75 acres) is given, while 8 picols is about the largest dose when large quantities must be given. Experiments have proven that it is better to give small amounts at short intervals. Fertilizing must be done not later than the end of October, in the first place for a better reaction, and also because the control is very difficult in half-grown cane.

Superphosphate is used on few estates. Potash is never applied. Compost is used in large quantities. It is sometimes spread on the loosened soil before planting, but better results are obtained when the compost is spread over the piles and brought slowly into the rows by each "drawing-up" of the soil to the cane stools. Also, waste molasses is used to improve the texture of the soil.

In certain localities in Java they sometimes irrigate their cane, especially while it is young, by backing up the water in the drainage ditches and allowing it to flow into the rows. The more common method of irrigation, however, and the

Fig. 11. As the cane grows, the ridges between the rows are gradually worked down, the soil being drawn around the cane stools.

one considered to be the better, is to water each stool separately by hand, the water being dipped out of the ditches with a long-handled dipper and poured onto the cane.

The sugar planters are allowed to irrigate their cane only up to the end of December. From that time until it is harvest the old cane can receive no water from the irrigation canals. The natives start their second rice crop in January; and as they already have one crop half grown, all of the available water is required for their rice. The rainy season in Java extends from October to April, and therefore the cane does not suffer very much for want of water until May. As the dry season comes on in earnest, however, the cane begins to show the effects of the drought, and some varieties go off rather quickly. To conserve the moisture in the soil as much as possible it is a common practice to fill up all of the drainage ditches at the close of the rainy season.

> Nearly all irrigation water is divided by government officers and controlled by them. Permits are given for fourteen days, after which time new permits are given. These permits mention quantity and hours during which this quantity must be used. If there are plenty of laborers it is considered best to imitate rainfall; if only few laborers are available, or when there is plenty of water, the rows are inundated.
>
> The *first* (not the *second*) rice crop is started about November, so that in the months of November to May, and later, irrigation water is given to the sugar estates only when there is more than enough for the rice fields.

When the cane is mature and ready for grinding, each stick extends at least a foot below the surface of the soil, as we have already noted in discussing methods of cultivation. In harvesting, the sticks are pulled up if possible, but if the ground is so firm as to render this impracticable, the sticks are cut off well below the surface of the soil with a spade-like instrument. Two-wheeled bullock carts are largely used for transporting the cane from the fields, but many of the plantations operate rather extensive lines of railroad as well.

> On most estates the cane stools are not yet dug out, but I started to dig the cane stalks with levers and got such good results that several estates do or will do the same. Experiments done by Arendsen Hein, Muller von Czernicky, de Savornin Lahman and others proved that the root-end contained the largest percentage of sugar. It is estimated that by harvesting the whole cane stalks I obtained an additional 6 to 10 picols per "bahoe" (1.75 acres), so that for a small expense big profits were realized.

They have no labor problem in Java. Laborers are plentiful, and men, women and children are employed in various capacities in the cane fields. An ordinary male laborer receives 20 to 25 cents a day in Dutch money. This is equivalent to 8 to 10 cents American money. The women get 15 to 20 cents a day, and the children 10 to 15 cents. The planter has no responsibility so far as the food, shelter or medical attention of his laborers are concerned. The Javanese are natural agriculturists and make very efficient laborers. We have heard it said that the planters of Java can order out the natives in their district and compel

Fig. 12. Mature cane. The ridges between the rows are not only worked down, but the cane is actually hilled up as it matures, so that twelve to fourteen inches of each stick is buried in the soil. The variety is their seedling No. 100.

them to work in their cane fields. Nothing could be farther from the truth, however, for the natives are quite independent of the planters, and only work because they receive a suitable wage and are in need of the money.

> The wages for day labor are now higher, viz., 10 to 20 (American) cents for men, 8 to 12 for women, and 5 to 8 for children; but most work is paid in task, i. e., one furrow, 2 to 3 cents, etc.

The photographs accompanying these notes were supplied by Dr. Van der Stok from the files of the East Java Experiment Station.

Cane-Mill Work and Extraction Percentages.†

By T. Lely.

We are very much impressed in Holland by some recent figures of Hawaiian mill results which state an amount of sugar in megass of 2 per cent, but I am also struck by a statement that in Cuba they prefer rapid work even at a loss of from 4 to 5 per cent of sugar in megass on account of labor prices. This last statement sounds to me like an anachronism, to be satisfied to lose an important percentage of the stuff for which you plant, reap and manufacture. That it pays to grind the largest possible quantity of canes per hour is true, but only so long as it *pays* to lose some of the substance you manufacture. The problem of crushing is to be put this way: do I lose if I extract more sugar from the canes? and this question is answered by the figure of cost extraction per ton of sugar with bad and good crushing, and to this question mechanical knowledge answers that the increased cost of increased extraction remains below the value of the sugar up to the very last molecules of sucrose. This is theoretical, and in practice we may not obtain a sugarless megass, but a megass with less than half a per cent of sugar like the pulp of the beet factories is very well imaginable, since there is not such a great difference between the two materials.

A better crushing result is aimed at by the installation of more mills, one after the other, and a calculation of the time of crushing is rather interesting. Say the mill speed is 25 per cent per minute and the line of highest pressure is 3 inches broad, this gives a time of high pressure of not quite one second in one mill for the back roller or a total of one and a third seconds; this means for four mills not more than five seconds of highest pressure. From hydraulic experiments we know that with a much lower pressure, but during a longer time, we obtain megass in which the moisture can be reduced to even 7 per cent, and as it costs nothing to maintain the pressure on the material during a longer time, the immense gain due to longer pressure is evident. For comparison we must look at the extraction of oil from oil seed, where some interesting physical points ask

† Louisiana Planter, June 7, 1919.

for attention. Oil seed is steamed hot to reduce the viscosity of the liquid contents. The same effect will be exercised on mill juice when heating the canes before crushing. This might be done by immersing the canes when unloaded in a scalding vat as they do pigs in the Chicago meat establishments. The stalks would not take heat rapidly from a steam bath, but water contains in the same volume so many more calories that in about 3 to 5 minutes the canes will be thoroughly hot and part much more readily with the juice. Some sugar of the cane ends will dissolve, but some water will adhere to the canes and the replenishing may be a sufficient refreshing of the bath which otherwise must be drawn off to a certain percentage and go to the evaporators or be used for maceration.

This scalding of the canes has for second effect the result that the cell walls become parched like the chips of beet in the diffusion bathing, and offer no elastic resistance to the mill pressure. This is the reason why almost all the juice will come out at the first mill, and the megass will not absorb much water on maceration. As has been said, the mill speed must be so slow that the juice has time enough to escape, and the megass has time to part with what it can lose. Now, it will part with all it can part with even on a very narrow line of pinching, but we must not go to the splitting limit; it is better not to exceed this limit, which is the criterion in the matter of capacity.

With scalded canes, in order to obtain an equal pressure, I would increase the thickness of the megass layer between the top and back roller to ½-inch, the dimension of a linseed oil cake, which layer being 6 to 8 times the thickness of the now used back opening, would allow us to run the mills six to eight times slower, causing far less variation in the mill pressure and assuming the same results as of a good pulp press. We may expect a megass with only 12 to 15 per cent of moisture or one-third of the present quantity, which, considering the impurity of the last expressed juice, would mean a sugar content of perhaps ½ per cent. The scalding vat seems a very suitable apparatus; it will consist of an immersed transporting carrier, above which a second one comes with slats to keep the canes immersed, breadth-equal to roller length, depth 2½ feet, length 50-75 feet, heated by steam injection. The scalding of the canes gives us further an immediate sterilization of the juice, the albumine will be coagulated and the hot juice is limed and at once worked up without time for fermentation or inversion. To work up the juice quickly I would overlime it as it comes from the mills with a temperature of some 75 degrees C. to an alkalinity of 0.15, and, when completely stirred, reduce the alkalinity to neutral on neutral phenolphtalein paper; then heat to a temperature of 95 degrees C. and filter the whole body of juice through presses. By this method is avoided the whole time, labor and equipment of subsiding and scum station.

The time required for filtration depends more on the amount of sediment than on the bulk of the juice which passes through the cloth almost without loss of time (see how much cold, distilled water passes through a filter of 4 inches diameter, through the paper, almost unhindered). For ordinary use we need about 2½ square feet per ton of canes; total filtration will require about 3 to 3¼ square feet. The juice has no time to become sticky and we get the juice at the triple effect from the mills in about one-half hour's time. Not only will scalded canes give a much higher crushing figure, but the mill capacity may be much increased

thereby. An experiment with scalded canes is easily made in a hand mill, dividing a lot in two parts, scalding one part and comparing results of crushing by two or three times passing them through the mill with or without maceration and crushing slow and heavy.

The writer would be pleased to hear of the results of such an experiment. The attempt to heat the megass of a first mill has been made, but without success. In my opinion such megass is far too coarse to be rapidly heated; the scalding of the canes would take perhaps only two minutes and give us hot juice, reduced crushing power, low sugar and moisture in the megass, with increased fuel value. The present figures of Hawaii are obtained with far too much mill per ton of canes and can still be improved considerably.

Steaming of the megass of the first mill seems to me possible only when the canes have passed first through a Newell or Searby shredder. The scalding vat would make the Searby quite superfluous because the canes will become very brittle and the first mill will make dust of them without any preparation.

Some New Phases of the Problem of Preventing Sugar Deterioration.†

By Dr. Nicholas Kopeloff and Lillian Kopeloff.

The problem of preventing sugar deterioration in storage concerns every one interested in the production and distribution of marketable sugars, and represents a practical problem whose solution depends on the progress of scientific investigation. Since 1851 this problem has involved the lowest forms of plant life, which are microscopic in size—namely, the bacteria and molds. The fact that bacteria are to be found in practically all stored sugars has been responsible for much experimentation in determining their power to invert sucrose. More recently, however, attention has been directed to the increasing importance of molds in causing an inversion of sucrose in cane sugar. The present abstract represents a summarized discussion of the experimental data presented in detail in a bulletin now in press (Louisiana Bulletin No. 166) to which the reader is referred for a consideration of tables, historical sketch, acknowledgments, etc.

A comprehensive survey was undertaken to establish the different kinds of molds to be found in the various types of cane sugar. The samples under investigation included sugars from different sources and represented a considerable range in composition, age and keeping quality. They comprised grades of plantation granulated, yellow clarified, 96-degree test, Cuban raw and seconds. Each sample (about 100 in all) was planted out in triplicate on eight different agar media, which included one developed by the authors which proved to be especially satisfactory for the isolation of molds, the composition being:

† Louisiana Planter, April 12, 1919.

Water	1,000 cc.
Sucrose	50.0 gm.
Peptone	5.0 "
NH_4NO_3	1.0 "
K_2HPO_4	1.0 "
KCl	0.5 "
$MgSO_4$	0.25 "
$FeSO_4$	0.01 "
Agar	20.0 "
Reaction	+ 1 Fuller's scale

The results indicated that two molds, *Aspergillus niger* and *Blue Aspergillus,* appeared in practically every sugar examined, and *Cladosporium* occurred in 90 per cent of the cases, while about 30 other molds were found less frequently. In many samples of sugar the molds were found in the mycelial or actively-growing stage as well as in the spore or resting stage. It is noteworthy that these common molds are to be found universally in air, soil, and organic material of all kinds. The lower grades of sugar had a greater mold flora, both qualitatively and quantitatively.

THE DETERIORATION OF SUGAR BY PURE CULTURES OF MOLDS.

Having isolated the molds, the next logical step was to inoculate sterilized sugars with those molds which had appeared with greatest frequency in order to test their powers of producing inversion. Plantation granulated, refined and Cuban raw sugars representing the widely divergent types were employed, and the moisture content was at a minimum. Only the slightest signs of inversion, as evidenced by an analysis of sucrose, reducing sugars and moisture, were noted after four months in the plantation granulated sugar with a factor of safety ratio of 0.10 and in Cuban raw sugar with 0.20. This established the lower limit of moisture for the deterioration of cane sugar by the molds employed. No mycelia could be found in any of the samples, although the molds were found to be present by the plating method.

In order to approximate more nearly the optimum conditions for the activity of these organisms, an experiment similar to the above was conducted, with one important difference, namely, the sterilized sugars were permitted to absorb moisture in the autoclave before inoculation. Rapid deterioration occurred in one month where the factor of safety was in the vicinity of 0.30. The *Blue Aspergillus*, which was the mold appearing with greatest frequency in the isolation studies, was found to have the greatest capacity to cause inversion, being responsible for a loss of 2.4 per cent sucrose in one instance. *Aspergillus niger* was only slightly inferior in its deteriorative power. A microscopical examination revealed the presence of mycelia in several instances where deterioration had occurred. However, in other instances where deterioration was noted, no mycelium could be detected and only spores were present. This led to a study of the possible enzyme activity of the spores of molds.

It was found that the spores of the two most important molds actually in-

verted 10 and 20 per cent sucrose solutions when analyzed after 3 hours' incubation at 45 degrees C., thus proving that the mold spores contained the enzyme, invertase. Furthermore, the *Blue Aspergillus* contained an enzyme capable of forming a gum in the sterilized sugar solution. Since the spores of molds secrete enough invertase to cause the deterioration of sugar without the development of mycelia, then sugar which has heretofore been regarded as safe by virtue of its factor of safety, would in reality be likely to undergo deterioration, depending upon the nature and extent of the infection. In other words, it becomes imperative to exclude the spores of molds as much as possible, which points indubitably from a new angle to the necessity of cleanliness in the sugar house.

MOLDS IN THE FACTORY.

Having isolated the molds which occur in cane sugars and determined their power to cause deterioration by inversion, it was of practical significance to trace the fate of the molds and bacteria through the sugar manufacturing process. With this end in view a daily mycological and bacteriological examination of each stage in the process at our mill was carried on throughout the past grinding season. Samples were aseptically collected, and plated immediately in four dilutions of Kopeloff's agar. The average of the results expressed in per cent, assuming that of the raw juice to be 100, is as follows:

	Molds.	Bacteria, etc.
Raw Juice	100	100
Sulfured Juice	13.6	1.14
Limed Juice	3.3	0.17
Filtered Juice	1.6	0.51
Settled Juice	0	0.28
Syrup	24.6	0.10
Massecuite	31.1	0.11
Raw Sugar	91.8	.06
Washed Sugar	85.2	.08
Molasses	28.0	.27
Wash Water	0	.13
Air Above Centrifugal	11.5	.001
Air Below Centrifugal	32.8	.006

It is at once evident that the greatest number of microorganisms occurs in the raw or normal juice. Sulfitation causes a decrease of 86 per cent in the number of molds, while the completion of the clarification process renders the juice practically sterile. However, when the syrup and massecuite are exposed to the air, and especially when the latter enters the centrifugal, reinfection takes place. The rapidly whirling centrifugal sucks air from below at great speed, and any microorganisms on the floor or in the mill at large have an opportunity of gaining an entrance. This is corroborated by the fact that the air below the centrifugal has approximately three times as many molds as the air above the centrifugal. The bacterial counts (which include microorganisms other than molds) follow the same general trend as the molds.

PRACTICAL DEDUCTIONS.

Since the deterioration of infected sugar is accelerated by the presence of moisture, it is again essential to emphasize the necessity for reducing the moisture content of cane sugar and avoiding the subsequent access of moisture. It has been shown in the preceding paragraphs that re-infection takes place on a large scale after the massecuite leaves the vacuum pan; it would, therefore, be advisable to cover the mixer which conveys the massecuite to the centrifugals. This might very easily be accomplished by means of an adjustable and removable canvas or tarpaulin. In this way all dirt, dust and foreign matter, as well as microorganisms, could be excluded, and one of the sources of infection removed. Since the principal infection occurs at the centrifugal, and before the sugar is bagged, it is of practical importance to take special precautions at this point. If possible the centrifugals should be in a closed room instead of in the open factory, and it is essential that there be a concrete floor in any event. This should be kept clean throughout the day and a swabbing with a hot 0.5 per cent solution of formaldehyde would do much towards destroying contaminating influences. In the off-season it would be advisable to sterilize the mill thoroughly. Where water is used in washing sugars, strict regard must be paid to its purity, for, as is often the case, where the water is contaminated with microorganisms such practice is equivalent to an inoculation of sugar with deteriorative organisms. There is no question but that closed centrifugals would be decidedly advantageous.

The possibility of actually sterilizing the sugar and washing by means of superheated steam in the centrifugals is now being studied. That the handling of sugar after it leaves the centrifugal requires care, is self-evident, and the condition of the bags must not be disregarded in any consideration of infection by molds or bacteria. The proper storage of sugar requires a cool, dry, well-ventilated warehouse. In piling bags it would be poor policy to place bags which may have been accidentally torn in transit, near the middle of any single pile, for the reason that its exposure to infection which might result in considerable deterioration, would cause it to spread to bags below by virtue of the pressure exerted upon it from above. The best procedure to be followed to militate against such a condition, when unavoidably occurring, would be to have all bags which are badly torn, sewn up, or, if this is impossible, to keep such bags piled together and not permit them to be scattered through the piles having satisfactory bags. In conclusion, then, it may be stated that it is necessary to guard against all sources of contamination, thereby reducing infection, which means the elimination of one of the principal factors in deterioration.

SUMMARY.

1. The molds appearing with greatest frequency in cane sugar of different grades belonged to the common *Aspergilli* and *Penicillia*. Mold mycelia were found in sugars. An efficient agar medium was developed for the isolation of molds from sugar.

2. Sterilized sugars inoculated with pure cultures of mold deteriorated rapidly where the factor of safety was about 0.30. Little, if any, deterioration occurred where the moisture content was reduced to a minimum.

3. Some molds cause an inversion of sucrose where only spores are present, as well as when mycelia are developed. Spores of some molds contain the enzyme invertase, and also a gum-forming enzyme.

4. The *Aspergilli* appearing with greatest frequency on all sugars had the greatest deteriorative powers.

5. Sugars ordinarily guaranteed against deterioration by virtue of the factor of safety rule are capable of undergoing deterioration if sufficiently infected by molds, because of the invertase in the spores and mycelium.

6. Molds and bacteria traced throughout the sugar-making process were found in greatest numbers in raw juice. The clarification process was, in fact, a sterilization, but re-infection took place in the massecuite and in and about the centrifugals.

7. The practical deductions involve cleanliness throughout the factory to guard against infection, especially in the vicinity of the centrifugals, and adequate storage facilities. [W. R. M.]

Lubrication of Air Compressors.†

By H. V. Conrad.

Satisfactory lubrication of air compressor cylinders is attained by securing (1) the reduction of friction to a minimum, and (2) elimination of carbonization of the oil as far as possible.

For the proper reduction of friction, the oil chosen should have sufficient body to sustain the weight of the moving parts and to form a seal between the piston rings and the cylinder walls, and still not absorb excessive power in the overcoming of the viscosity of the oil itself.

The objections to air cylinder oils, which allow more than the very slight amount of carbonization which appears unavoidable, are, of course, well known, but may be briefly stated for the purpose of clarifying what follows:

Carbonization of the oil allows the accumulation of deposits of carbon, which are sticky in the early stages of their formation but hard and flinty later. Such deposits accumulate on the cylinder valves, in the cylinder passages, in the pipes and eventually in the air receiver.

Sticking or partial closing of the valves and their consequent failure to act properly is probably the chief objection to this action from the standpoint of the efficient operation of the compressor.

The formation of excessive carbon deposits is apt to be due to any one or more of the following causes:

1. The ill-advised use of some oil, such as a steam cylinder oil, which easily decomposes in the heat of the air cylinder.

2. The use of oils of too great a viscosity—commonly referred to as "too heavy oils." These do not atomize readily, and, therefore, remain too long upon the hot cylinder walls, etc., thus baking down to sticky carbon deposits.

3. The use of too great quantities of oil which has the same effect as the use of too heavy an oil as far as the carbonization is concerned.

4. The failure to provide a proper screen over the air intake of the compressor, thus allowing free entrance of dangerous dust (especially coal dust).

The objections to this carbonization, aside from the sticking of air valves and choking of the air passages, is the menace of fire entailed by carbon deposits. Carbon particles torn loose from them may become incandescent from causes which could not be anticipated by the compressor manufacturer. If such incandescent carbon particles should happen to come in contact with "oil vapor" given off by the lubricating oil, a fire might possibly be started whose menace would be small or large depending upon how much carbon had been allowed to accumulate in the compressor and piping to the receiver. If these are kept properly cleansed at all times there should never be a time of any danger.

This oil vapor is given off from a lubricating oil at a certain temperature called its "flash point," just as steam arises from water at a certain point.

HEAT OF AIR COMPRESSION.

The selection of an air cylinder lubricant is, of course, governed to a considerable extent by a knowledge of cylinder temperature it must withstand. Knowing the air pressures, the corresponding temperatures are ascertained fairly accurately, as shown in Table No. 1.

This table gives the final temperature in the cylinder at the end of the compression stroke, for single stage, also for two-stage (or compound) compression, when the free air entering the cylinder is 60 deg. F.

TABLE NO. 1—CYLINDER TEMPERATURES AT END OF PISTON STROKE.

Air compressed to—	Final Temperature, Single Stage	Final Temperature, Two Stage
10 lb. gauge.........	145 deg. F.	....
20 lb. gauge.........	207 deg. F.	....
30 lb. gauge.........	255 deg. F.	....
40 lb. gauge.........	302 deg. F.	....
50 lb. gauge.........	339 deg. F.	188 deg. F.
60 lb. gauge.........	375 deg. F.	203 deg. F.
70 lb. gauge.........	405 deg. F.	214 deg. F.
80 lb. gauge.........	432 deg. F.	224 deg. F.
90 lb. gauge.........	459 deg. F.	234 deg. F.
100 lb. gauge.........	485 deg. F.	243 deg. F.
110 lb. gauge.........	507 deg. F.	250 deg. F.
120 lb. gauge.........	529 deg. F.	257 deg. F.
130 lb. gauge.........	550 deg. F.	265 deg. F.
140 lb. gauge.........	570 deg. F.	272 deg. F.
150 lb. gauge.........	589 deg. F.	279 deg. F.
200 lb. gauge.........	672 deg. F.	309 deg. F.
250 lb. gauge.........	749 deg. F.	331 deg. F.

Variations from these temperatures will occur in actual practice, due to water-jacketed air cylinders and radiation, tending to lower the temperature at the higher pressures. But at, say, 50-pound pressure and lower, the heat is likely to be somewhat greater than given by the table, particularly if the compressor is run at high speed and also if it is not water-jacketed.

RELATION OF OIL FLASH POINT TO CYLINDER TEMPERATURE.

The natural inference of the reader after noting the temperatures in Table 1 is that he must select an air cylinder oil whose flash point is higher than the maximum temperature apt to be encountered within the air cylinder. As a matter of fact, this is not the case, and it need only be carefully noted that the study of the air cylinder temperatures is useful mainly in testing lubricating oils to determine their resistance against breaking down into carbon, etc. But such temperatures cannot be taken as limits establishing the highest allowable flash point for a lubricant safe to use in the air cylinders.

QUALITIES OF CYLINDER LUBRICATING OILS.

For average normal conditions the oil should be a medium-bodied pure mineral oil of the highest quality, not compounded with fixed oils, such as animal or vegetable, and should be carefully filtered in the final process of manufacture.

Quite a range of oil composition is permissible for lubricants approved for this work, which are manufactured under the above conditions. Primarily a distinction must be made between those oils having a paraffin base as distinguished from those having an asphaltic base.

From a strictly operating standpoint—so it is claimed by some lubricant manufacturers—there is no distinction between these two classes of lubricants as to their desirability as compressor cylinder oils, provided that both have been properly filtered in the process of manufacture to remove the carbon-forming elements. If any carbon should be formed, however, such carbon deposited by the asphaltic base oils is of a light, fluffy nature and easily cleaned out, whereas that deposited by the paraffin-base oil is very adhesive and characterized by the hard, flinty nature.

PARAFFIN-BASE LUBRICATING OILS.

Merely as a guide to aid the operator in specifying the qualities to be possessed by an air cylinder lubricant recommended for average duty, the following table is presented:

TABLE NO. 2—PHYSICAL TESTS OF PARAFFIN BASE OILS.

	Minimum	Average	Maximum
Gravity, Baumé	28 to 32 deg.	25 to 30 deg.	25 to 27 deg.
Flash Point, Open Cup	375 to 400 deg. F.	400 to 425 deg. F.	425 to 500 deg. F.
Fire	425 to 450 deg. F.	450 to 475 deg. F.	475 to 575 deg. F.
Viscosity (Saybolt) at 100 deg. F.	120 to 180 sec.	230 to 315 sec.	to 1500 sec.
Color	Yellowish	Reddish	D'k Red to Green
Congealing Point (pour test deg. F.)	20 to 25 deg. F.	30 deg. F.	35 to 45 deg. F.

It is suggested that those oils within the range expressed by the minimum figures be used for light duty of low pressure and temperatures, while those expressed by maximum figures should be used for high pressures and temperatures.

TABLE NO. 3—PHYSICAL TESTS OF ASPHALTIC BASE OILS.

	Minimum	Average	Maximum
Gravity, Baumé	20-22 deg.	19.8-21 deg.	19.5-20.5 deg.
Flash Point, Open Cup	305-325 deg. F.	315-335 deg. F.	330-375 deg. F.
Fire	360-380 deg. F.	370-400 deg. F.	385-440 deg. F.
Viscosity (Saybolt) at 100 deg. F.	175-225 sec.	275-325 sec.	475-750 sec.
Color	Pale Yellow	Pale Yellow	Pale Yellow
Congealing Point (pour test)	0 deg. F.	—0 deg. F.	—0 deg. F.

TABLE NO. 4—QUANTITY OF AIR CYLINDER LUBRICANT REQUIRED PER 10-HOUR DAY.

Diameter of Cylinder, Inches	Size of Cylinder, Inches	Displace-ment per Minute, Cubic Feet	Piston Speed, Feet per Minute	Sq. Ft. of Cylinder Wall Swept by Piston	Drops Oil per Minute	Drops Oil per 10 Hrs.	Sq. Ft. Oiled per Drop	Number Pints Oil Required per 10 Hrs.
8	8 x 8	120	344	718	1	600	718	0.0375
12	12 x 12	320	408	1230	2	1200	613	0.0750
18	18 x 18	880	496	2340	4	2400	585	0.1500
24	24 x 24	1730	550	3450	6	3600	575	0.2250
30	30 x 30	2940	600	4700	8	4800	590	0.3000
36	36 x 36	4550	644	6070	10	6000	607	0.3750
42	42 x 42	6700	696	7600	12	7200	633	0.4500

* Figures of last column are based upon an estimated 16,000 drops per pint of oil at 75 degrees Fahr.

It is recommended that any paraffin-base lubricant intended for use in "all standard air compressors" should meet the physical tests imposed by the average range of figures given in the middle column of the above table. The above wording, "standard air compressors," is to be interpreted as including the following types of machines:

a. Low pressure up to 100-lb. compressors, which may be either small single-stage units or larger-sized compound machines.

b. High-pressure compressors which are constructed with the proper number of stages so that no excessive temperatures are ever reached.

In other words, this lubricant of average test figures is always recommended unless a compressor manufacturer specifies in his literature that a high flash point oil should be used to meet the conditions peculiar to his machine. It is thus obvious that it is never necessary that a lubricant should possess a flash point as high as 500 deg. unless abnormal conditions of high temperature prevail. Such high flash point oils have an unusual tendency to produce carbon deposits.

ASPHALTIC-BASE LUBRICATING OILS.

This group of oils is considered separately for the reason that the lower limit of gravity stated in the above table, viz., 25 deg. Baumé, eliminates this entire group from consideration—which is not the intention of this article.

As a guide for the selection of suitable oil, see Table No. 3.

For general all-around use, it is conceded that the recommendations given in Tables Nos. 2 and 3 above cover the situation as well as possible, special cases, of course, requiring investigation and special consideration before making recommendations.

PROPER QUANTITY OF LUBRICATING OILS.

The quantity of lubricating oil to feed to the air cylinders of compressors cannot be stated in exact terms due to the varying viscosity of different oils, the heat of compression and the size of cylinder. It may be stated in general, however, that after the cylinders have acquired smooth and polished surfaces, the quantity should be reduced to the lowest limit to avoid the possibility of the accumulation of carbon and sooty deposits within the system due to excessive use.

The following basis of quantity given in Table No. 4 is recommended, subject to above modifications for these cylinders or equivalent sizes, operating under normal conditions.

It will, of course, be carefully noted and clearly understood that the results in the last column of Table No. 4 are based upon the assumption that under average conditions of temperature and usual range of oil viscosities, a pint of oil will contain an average of about 16,000 drops. It is, of course, understood that these figures are offered merely as an approximate guide and that every individual must exercise his own judgment in modifying them wherever his own particular set of working conditions is unusual.

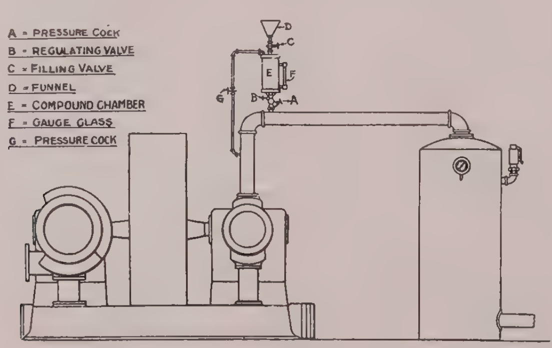
A leading authority on compressor engineering contributes the following: "The best way to determine the proper amount of lubrication is to take out the valves from time to time and examine the cylinder. All parts should feel that

there is oil thereon. If they feel dry, the lubricators should be adjusted to feed a little more oil, whereas if oil lies in the cylinder and its parts show excessive oil thereon, the quantity fed by the lubricators should be reduced. By thus examining the machine a few times, the proper amount of oil can be determined to suit the characteristics of the particular lubricant used and the conditions under which the machine operates." This is a better way to finally determine the quantity of oil required than by adopting without this experimenting any tabulated number of drops.

PERIODICAL CLEANSING OF SYSTEM.

The best of lubricating oils will cause the deposit of enough carbon in the compressor system to necessitate the periodical cleansing of it.

For the removal of carbon, the machine operator should confine his efforts to the use of soap suds. A good cleansing solution is made of one part soft soap to fifteen parts water. These suds should take the place of oil for a few hours and be fed into the air cylinders about once a week, either by means of a hand pump or through the regular lubricator at a rate about ten times as rapidly as that of the oil. The cleanliness of the air valves when inspected, as they should be periodically, will indicate whether greater or lesser applications of the soap suds should be made. After using soap suds, open the drain cock of the air receiver, and of the intercooler in the case of compound machines, to draw off any accumulated liquid. Oil should be used again for a half hour before shutting down the machine in order to prevent rusting the cylinder and its fittings. Never use kerosene, gasoline or lighter oils in an air cylinder for any purpose whatever, because of their volatile nature under heated conditions.



Compound:—Mix 1 lb. of Red Seal lye to 18 lb. of water.

To use compound: Close cock "A" and "G," open valve "C" and fill compound through funnel "D"; when chamber "E" is filled, close valve "C," open cock "G" and "A" and regulate feed by valve "B." Use about 70 drops per minute.

Device for cleaning carbon in air discharge line and receiver of air compressors.

CLEANING AIR RECEIVER AND PIPING.

It often happens that oil, carbon and other foreign matters are deposited in the air discharge lines and air receiver. A practical method of cleaning these is

shown in cut attached, where a receptacle made of 6-inch pipe is shown set on top of the discharge pipe. The cut shows plainly the construction and what the different parts represent. If a mixture of one pound of Red Seal lye and eighteen pounds of water is passed into the discharge line at the rate of 60 or 70 drops per minute, while the compressor is running, this will eat out all the accumulation on the surface of the pipe and in the receiver, and if the blow-off valve on receiver is open, all of this foreign matter will be discharged therefrom. This cleaning solution can be used every month or two or depending on how much accumulation there may be in the receiver.

STEAM CYLINDER LUBRICATION.

The proper quantity of oil to be fed to steam cylinder is much greater than to air cylinders, due to the constant washing away of the oil by the steam. Approximately four times as much oil will be needed in the steam cylinders as in those for air, subject, of course, to variable local conditions.

Depending on its viscosity, a pint of steam cylinder oil will furnish from 5000 to 8000 drops, and taking an average of about 6500 drops, and four times as much oil as air cylinders of same size, and working at same piston speeds, as given in Table No. 3, the recommended amounts to feed the steam cylinders or their equivalents are given in the following:

TABLE NO. 5—QUANTITY OF OIL FOR STEAM CYLINDER LUBRICATION.

No. Drops per Min.	Size of Cylinder, Inches	Number Pints Oil Required per 10 Hours
4	8 x 8	0.4
8	12 x 12	0.75
16	18 x 18	1.5
24	24 x 24	2.25
32	30 x 30	3.0
40	36 x 36	3.75
48	42 x 42	4.5

These figures are approximate only, and will vary with the steam conditions, the kind of oil used, and its method of introduction into the steam, also with the boiler compound carried by the steam into the cylinder.

OBSERVATIONS ON CHANGING TESTED OILS.

When the operator of an air compressor succeeds in obtaining lubricating oils that are giving satisfactory results, he should be very cautious about making a change to other grades, particularly if cheapening the cost is advocated by purchasing and sales agents. But if a change is decided on, the performance of the new lubricants should be most carefully checked up before damage can occur to the rubbing surfaces of the compressor, and to see that no increased amount of deposit collect on the inside walls of the air receiver.

The most satisfactory way to get the quickest results is to put up the problem of lubrications to the local experts of any reputable lubricating companies, and to be governed by their recommendations, which, however, should be based on the foregoing statement. [W. R. M.]

Plantation-Grown Stock Feed.

The Hawaiian Commercial and Sugar Company are using, in as great a measure as possible, a balanced feed ration for their plantation work and saddle stock, which is made up of 94% Island-grown products. They exhibited this feed at the Territorial Fair, and with it two saddle animals of their own breeding which have been raised and worked exclusively on this mixed feed, cane tops and pasture. At a time when imported feed-stuffs are such an expensive item on the plantations, such a balanced ration as is being used at Puunene by Mr. Ben Williams, ranch manager, is of special interest.

This ration is called "Circle P Sugar Bran," and has the following composition, 94% of the material being home production:

Recipe			Moisture, %
Soy Bean Meal	35 lbs.	6 %	11
Cane-top Meal	120 "	21 %	9
Hawaiian Alfalfa Meal	120 "	21 %	9
Cane Bagasse	50 "	8.7%	34
Cane Molasses	250 "	43.3%	21
		100 %	

The above 575 lbs. contains 40 lbs. digestible crude protein, 277 lbs. other digestible nutrients, and 480 lbs. dry matter. It is therefore 66% digestible, and has a nutritive ratio of 1:6.9. A 20-lb. ration of the above feed contains:

1.4 lbs. digestible protein,
9.6 lbs. other digestible nutrients,
3.4 lbs. moisture,

and conforming very closely to the modified Wolff-Lehman Feeding Standard* for horses (or mules) at medium work, viz:

Dry matter—16 to 24 lbs.
Digestible proteins—1.4 to 1.7 lbs.
Total digestible nutrients—12.8 to 15.6 lbs (per day per 1000 lbs. live weight).
Nutritive ratio—7.8 to 8.3.

The cost of this ration, as described above, is under thirty cents, and one would spend at least eighty-five cents to obtain an approximate feeding value by feeding oats and wheat hay, which would be the following feed per diem:

* Vide "Feeds and Feeding," Henry & Morrison, 16th Edit., pp. 669-71.

13 lbs. good oats,
15 lbs. wheat hay (as now imported),

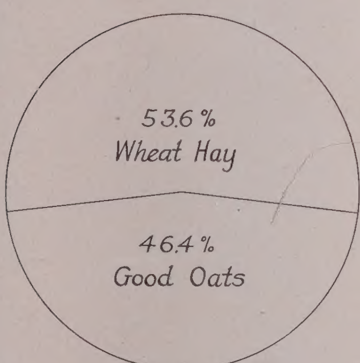
which would contain:

1.4 lbs. digestible protein,
13 lbs. other digestible nutrients,
2.6 lbs. moisture,

with a digestibility of 57%, and a nutritive ratio of 1:9.2.

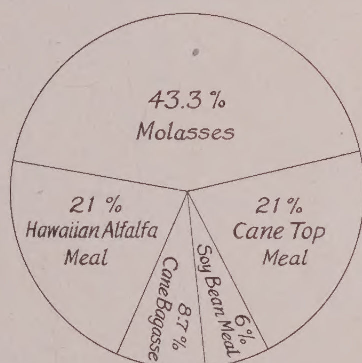
The following chart graphically compares the imported feed ration with the plantation-grown ration:

IMPORTED FEED RATION.
(Cost about 80 cents.)



1.4 lbs. Digestible protein.
13.0 lbs. Other digestible nutrients.
2.0 lbs. Moisture.

Ⓟ *SUGAR BRAN*
PLANTATION GROWN RATION.
(Cost about 30 cents per 20 lbs.)
94% Island Products.



1.4 lbs. Digestible protein.
9.6 lbs. Other digestible nutrients
3.3 lbs. Moisture

W. P. A.